

The life cycle of biofuels—the nitrogen problem

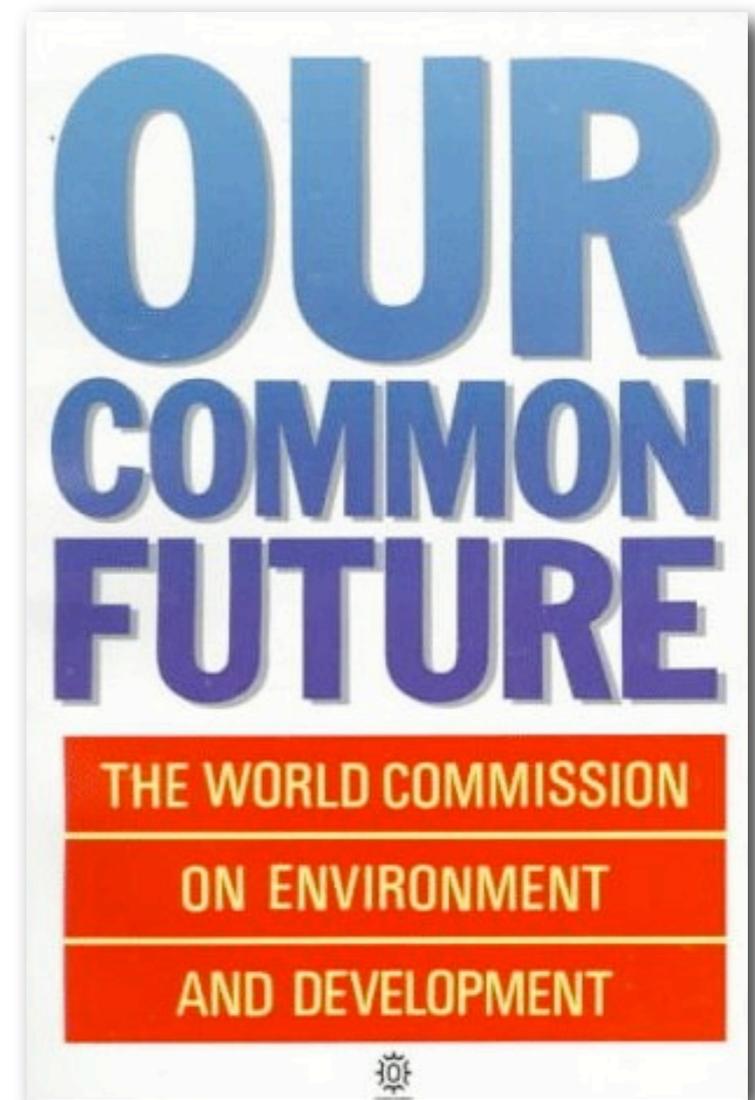
John Sheehan
Vice President Strategy & Sustainable
Development
LiveFuels™ Inc.

April 10 2008
Presented at
U.S. Environmental Protection Agency
Science Advisory Board



The idea of sustainability

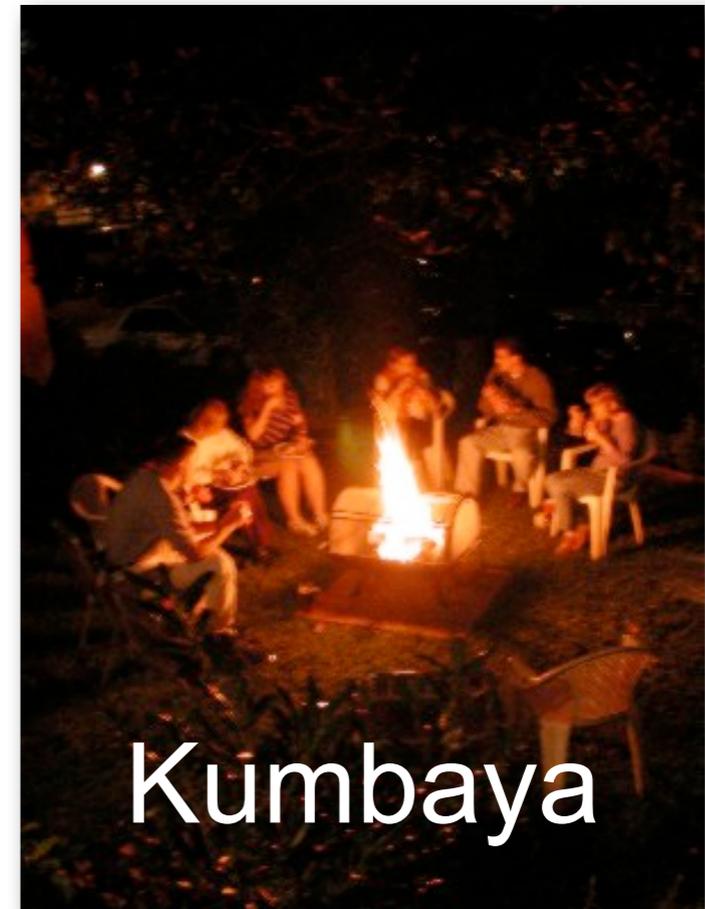
“Sustainable development meets the needs of the present without compromising the needs of the future generations.”



UN Commission (1987)

The idea of sustainability

“Sustainable development meets the needs of the present without compromising the needs of the future generations.”



UN Commission (1987)

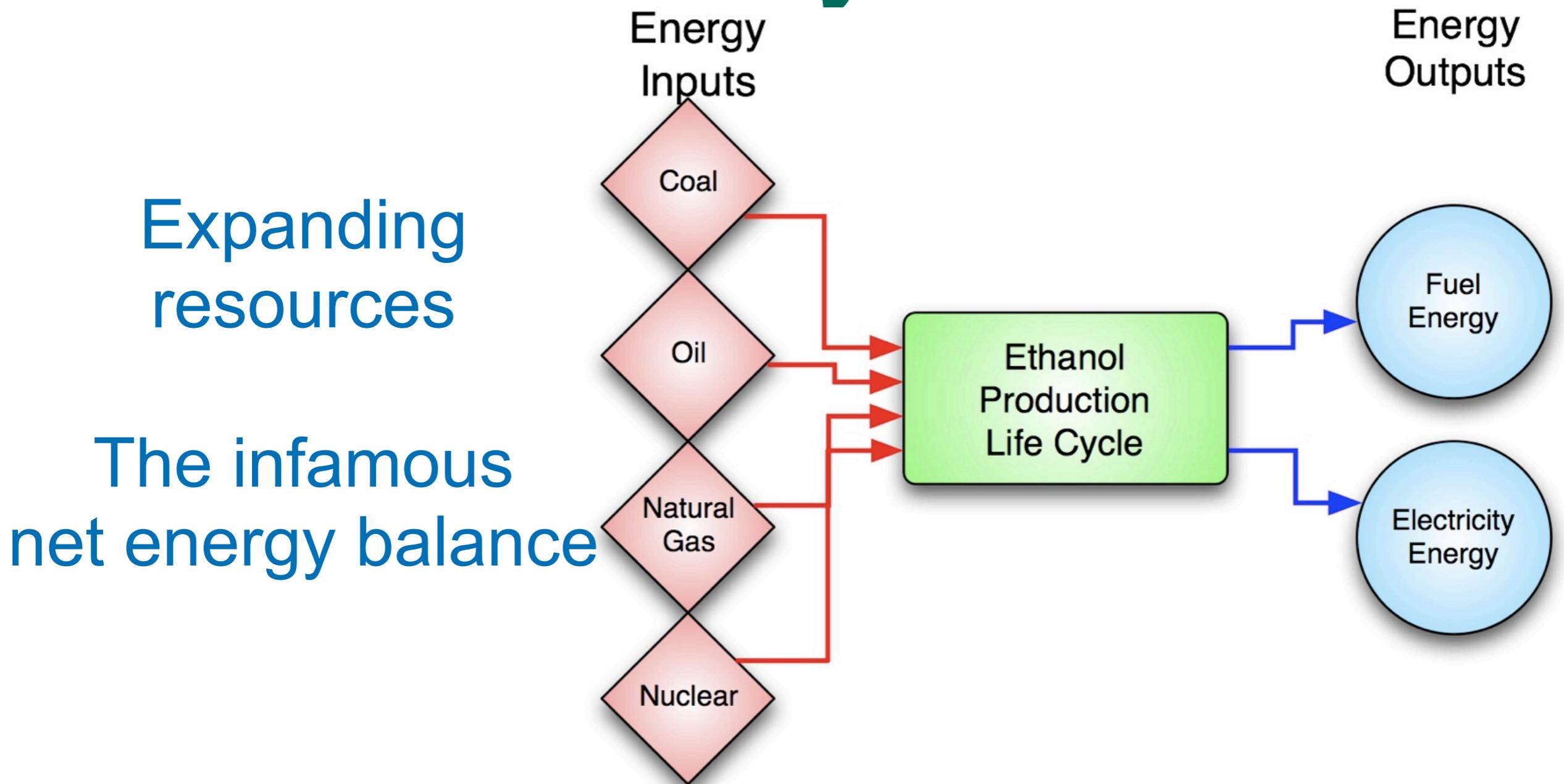
The idea of sustainability

“The common aim must be to **expand resources** and improve **quality of life** for as many people as heedless **population growth** forces upon **Earth**, and do it with minimal prosthetic dependence. That, in essence, is the **ethic** of sustainable development.”



E.O. Wilson, *Consilience*

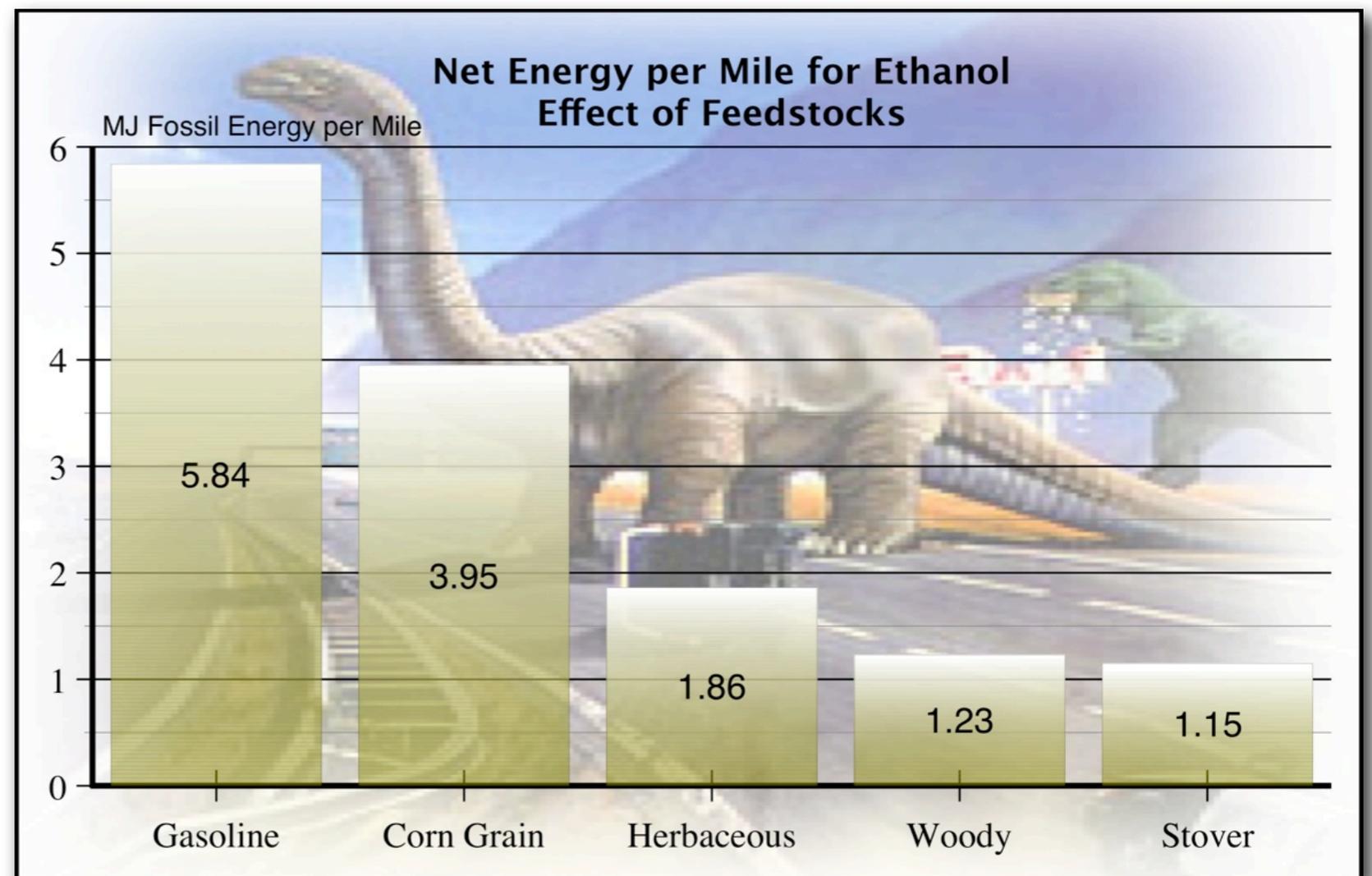
Tackling the sustainability of biofuels



Tackling the sustainability of biofuels

Expanding resources

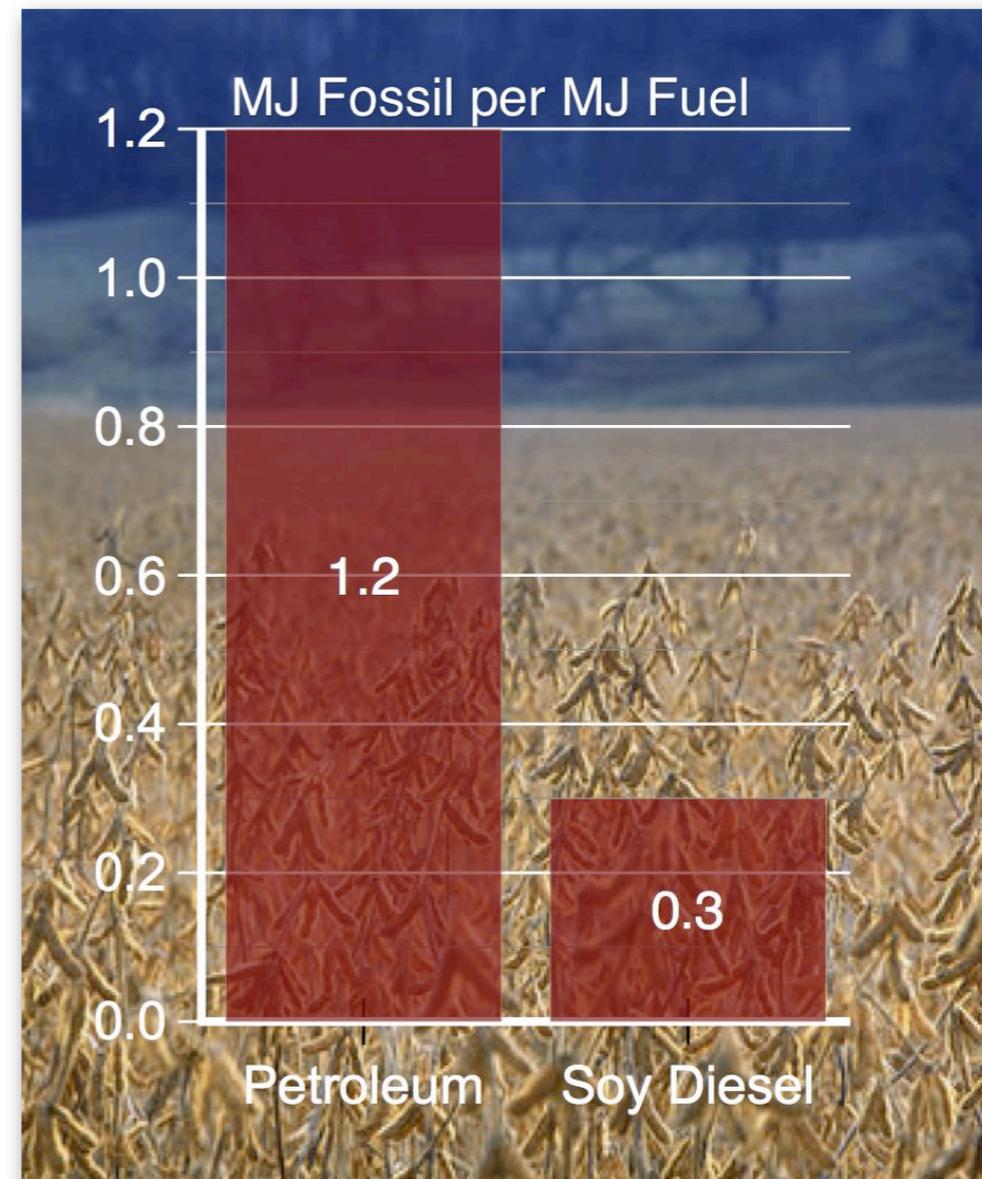
Ethanol and fossil energy use



Tackling the sustainability of biofuels

Expanding resources

Biodiesel and fossil energy use

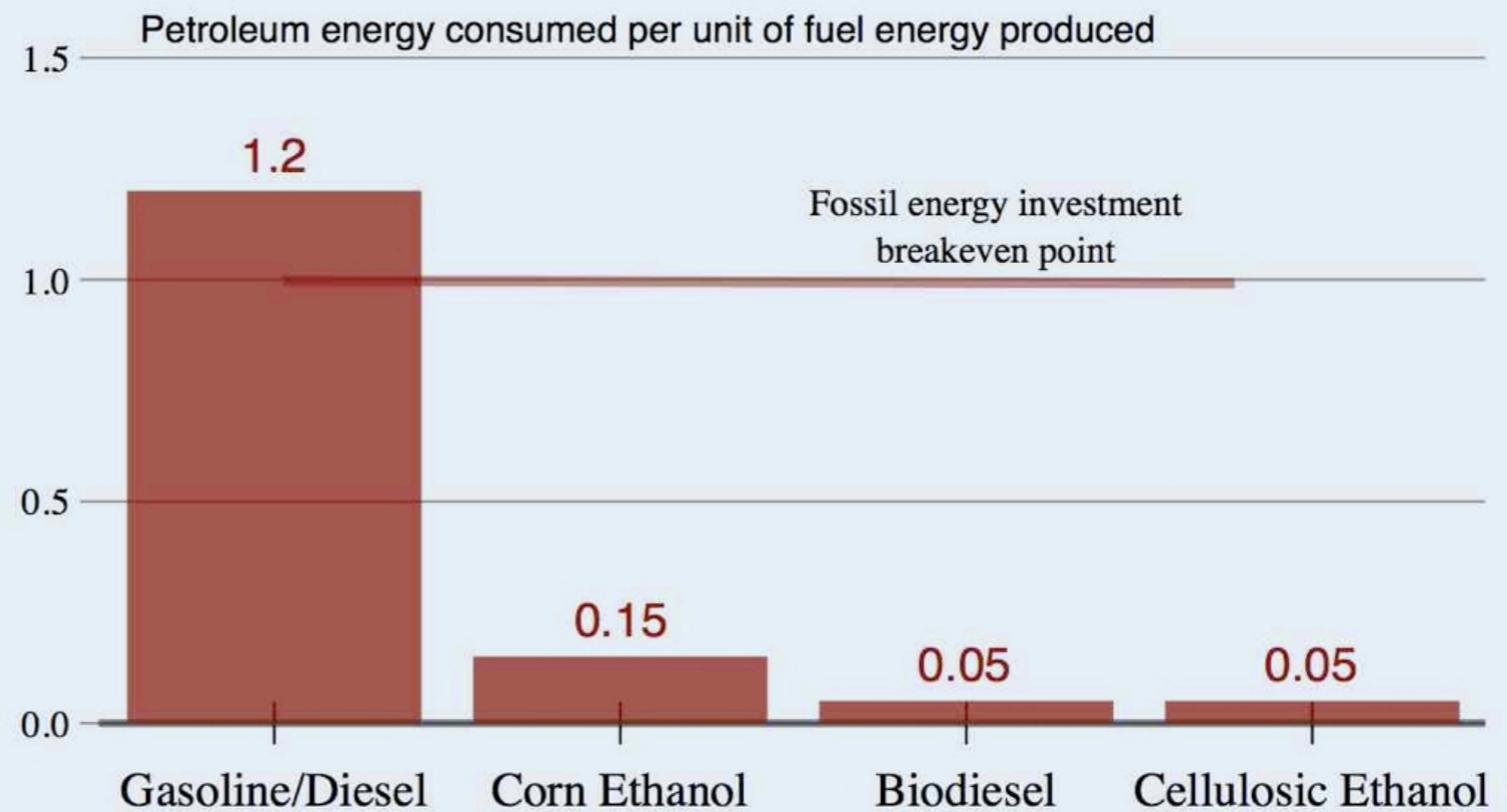


Tackling the sustainability of biofuels

Expanding resources

Biofuels and petroleum

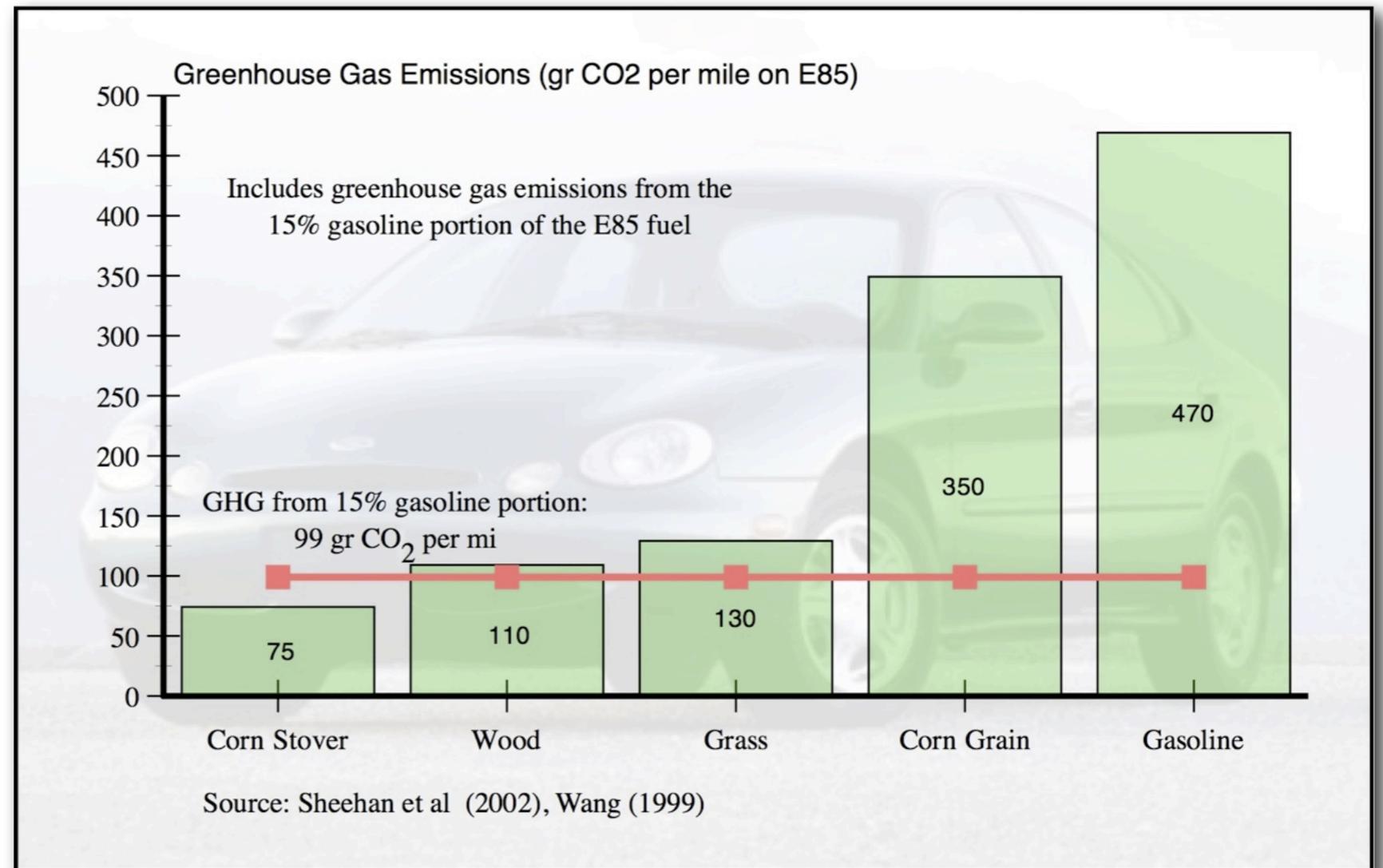
Leveraging petroleum usage with biofuels



Source: Wang (2002), Shapouri (2002), Pimentel and Patzek (2005), Sheehan(1998)

Tackling the sustainability of biofuels

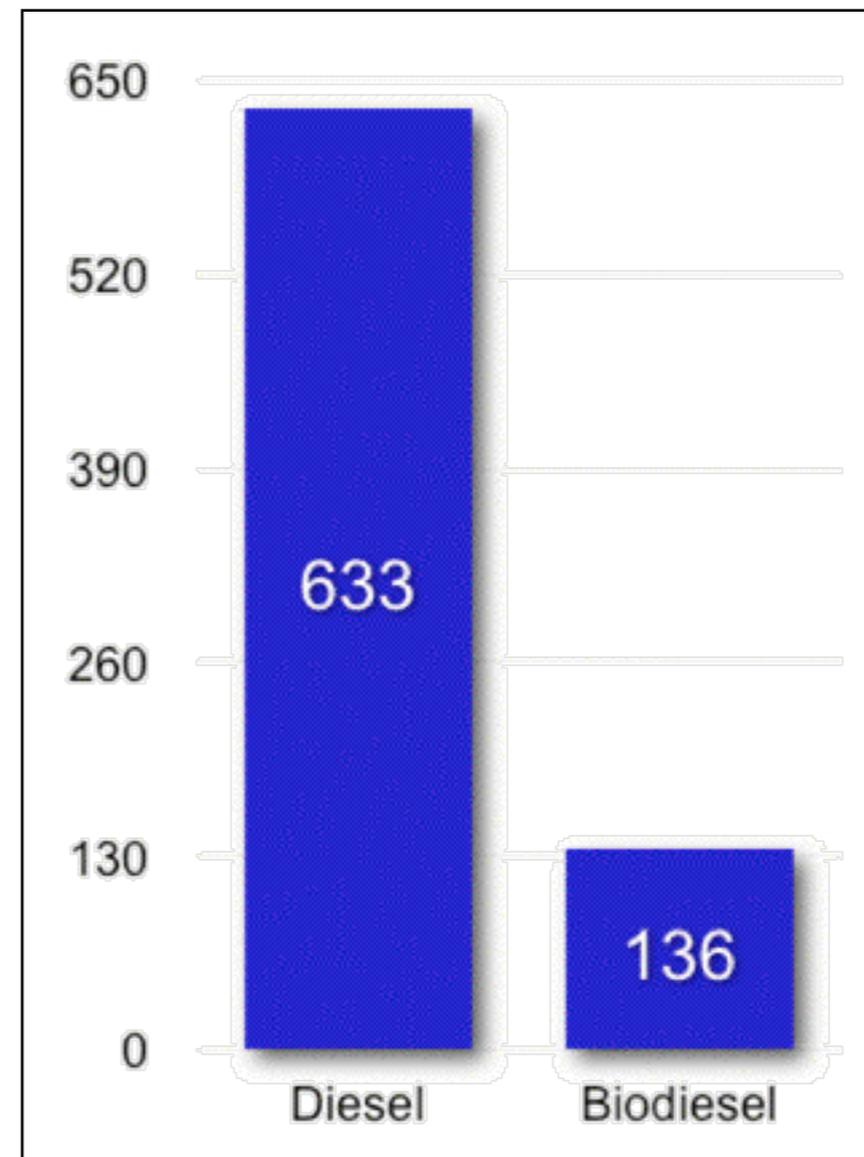
The Earth Ethanol and Greenhouse Gases



Tackling the sustainability of biofuels

The Earth

Biodiesel and
Greenhouse
Gases



Tackling the sustainability of biofuels

Land resources



Tackling the sustainability of biofuels

Land resources

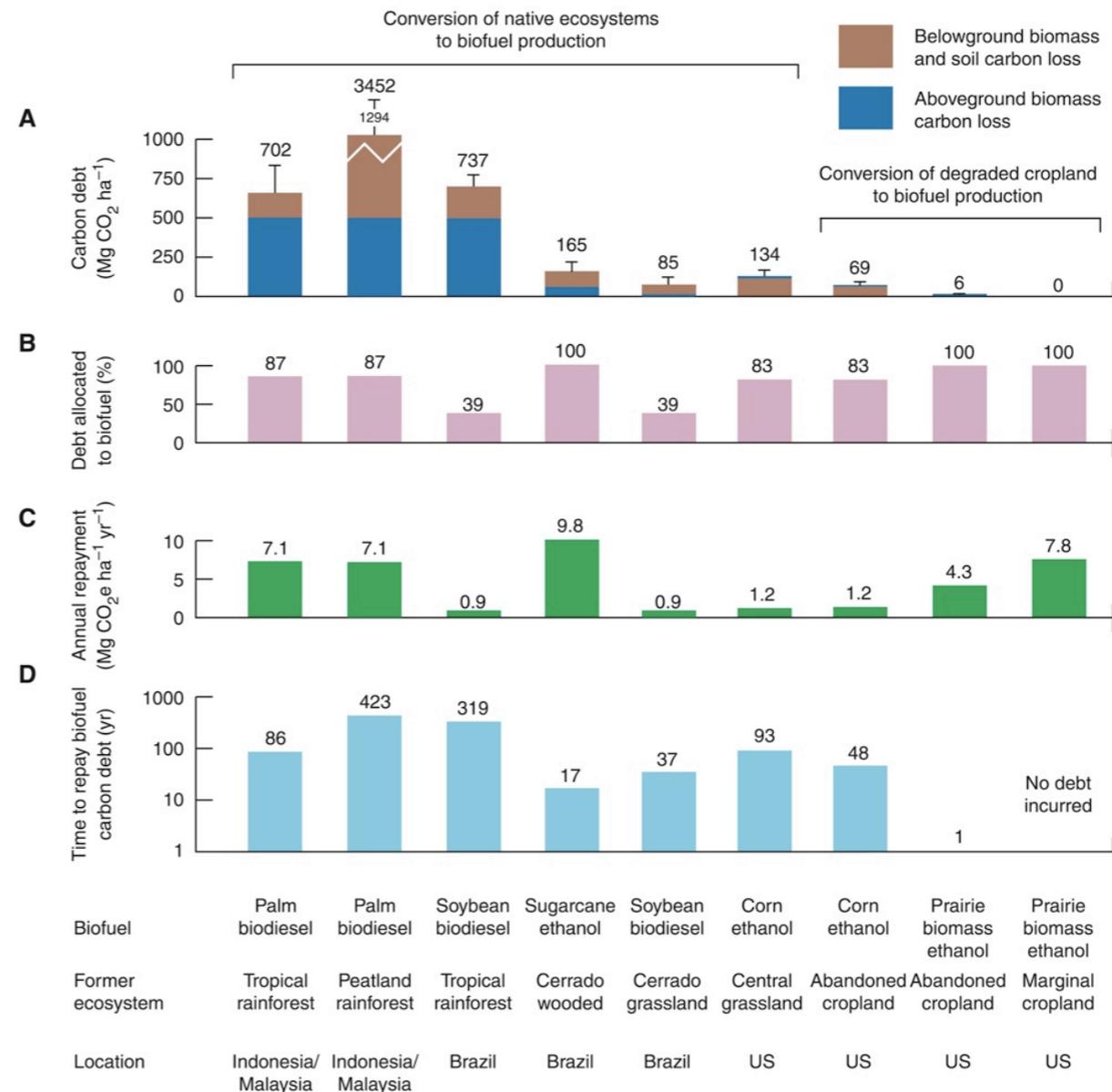


“EU did not foresee the problems raised by its policy to get 10% of Europe's road fuels from plants.”

BBC News January 2008

Tackling the sustainability of biofuels

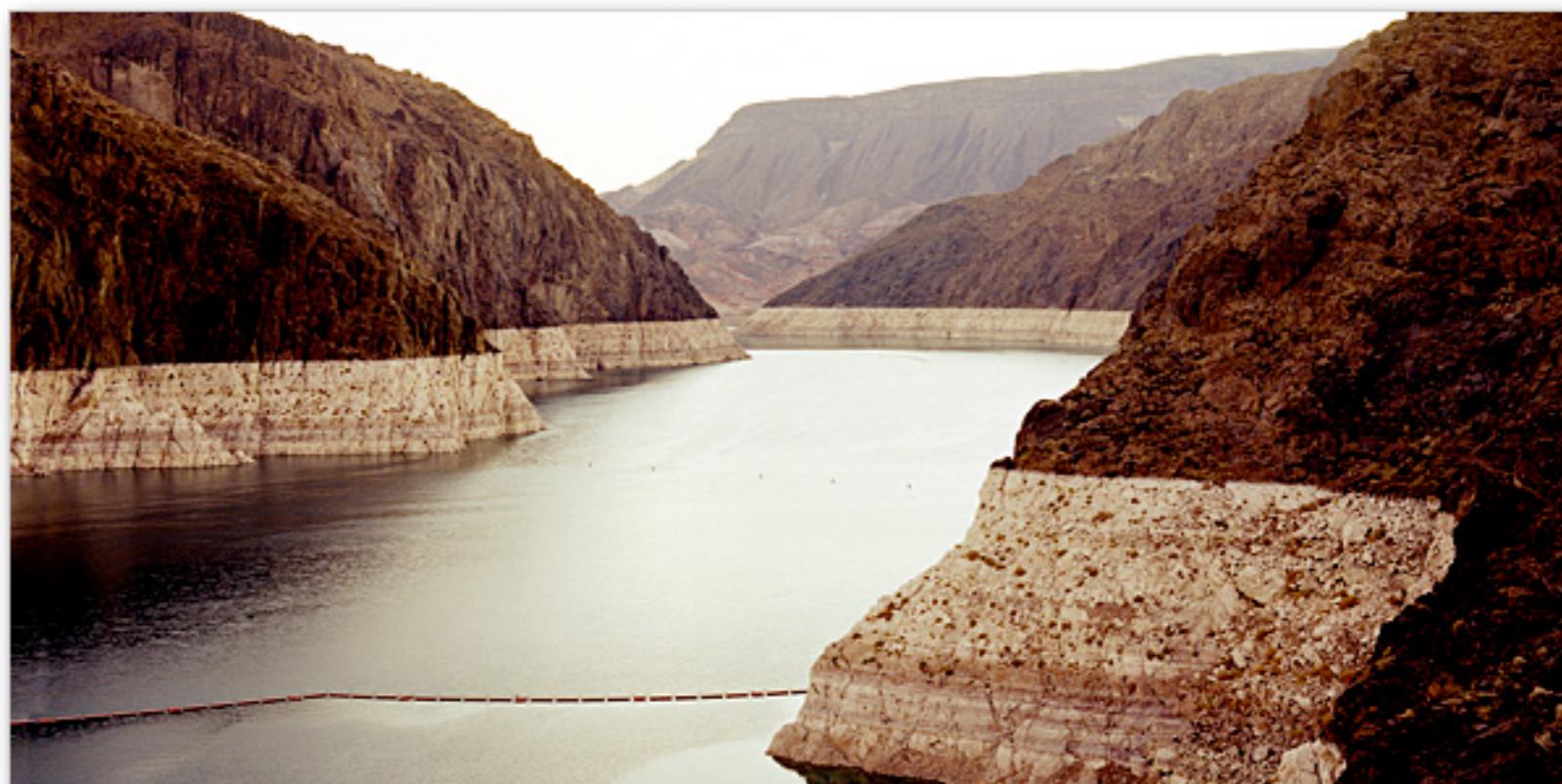
The effect of land use change on greenhouse gas emissions of biofuels



Tackling the sustainability of biofuels

Water resources

Can we afford
5 gallons of
water per gallon
of biofuels?



“The Future Is Drying Up”
The New York Times Magazine
October 2007

Nitrogen and biofuels

Is ethanol
from corn
stover
sustainable?

Adventures in
cyber-farming

A life cycle assessment
of the production of
ethanol from corn stover
for use in a flexible fuel
vehicle

Draft Report for Peer Review
December 23, 2002

John Sheehan, Andy Aden, Cynthia Riley
National Renewable Energy Laboratory
Golden, CO

David Lightle
Natural Resources Conservation Service
U.S. Department of Agriculture
Lincoln, NE

Marie Walsh, Janet Cushman
Oak Ridge National Laboratory
Oak Ridge, TN

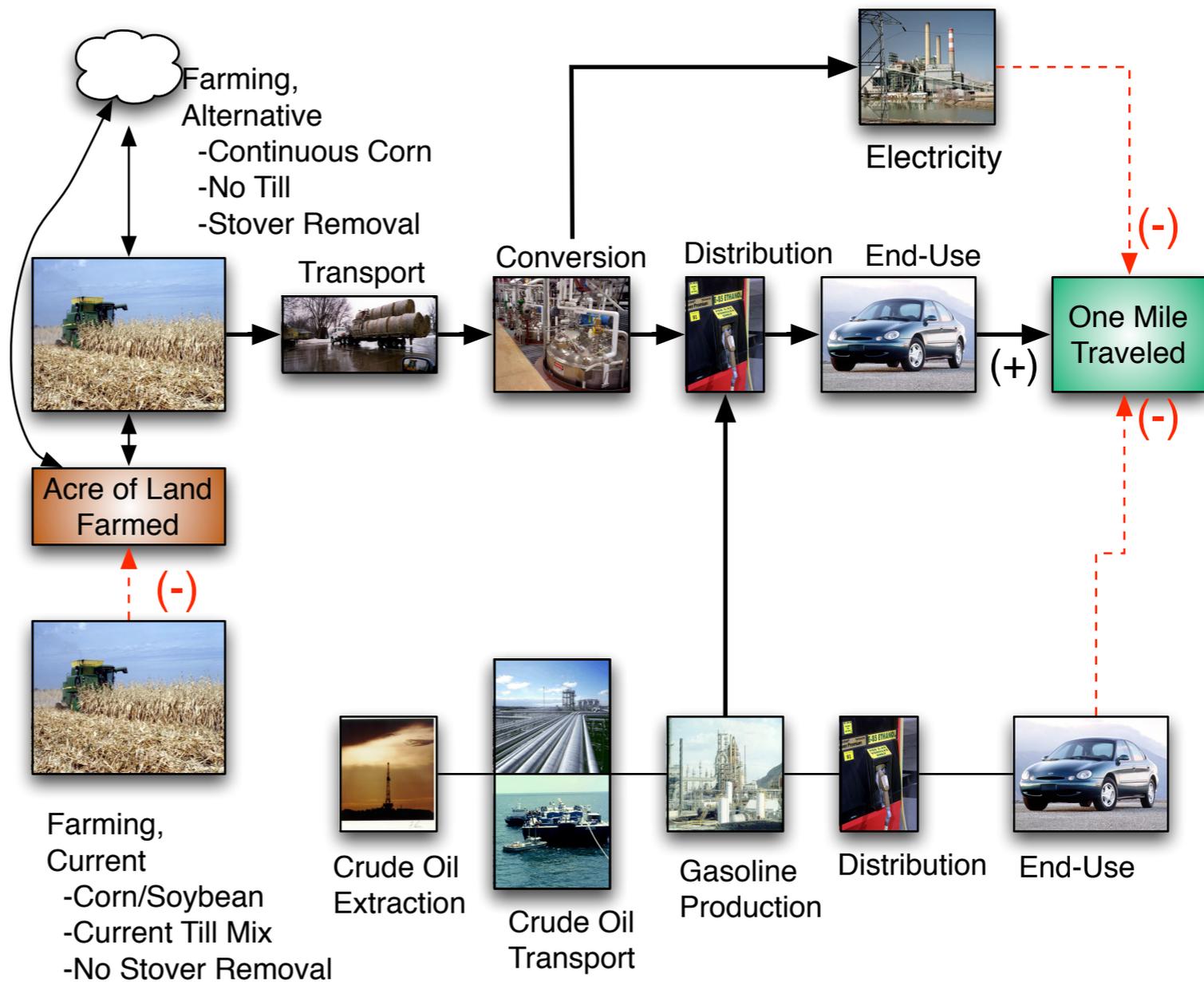


Keith Paustian, Ken Killian, John Brenner
Natural Resources Ecology Laboratory
Colorado State University
Fort Collins, CO

Richard Nelson
Kansas State University
Manhattan, KS

Tackling the sustainability of biofuels

Life cycle analysis
A directional system-wide perspective



Avoiding the average

Is bioethanol from corn stover sustainable?

Modeling Iowa

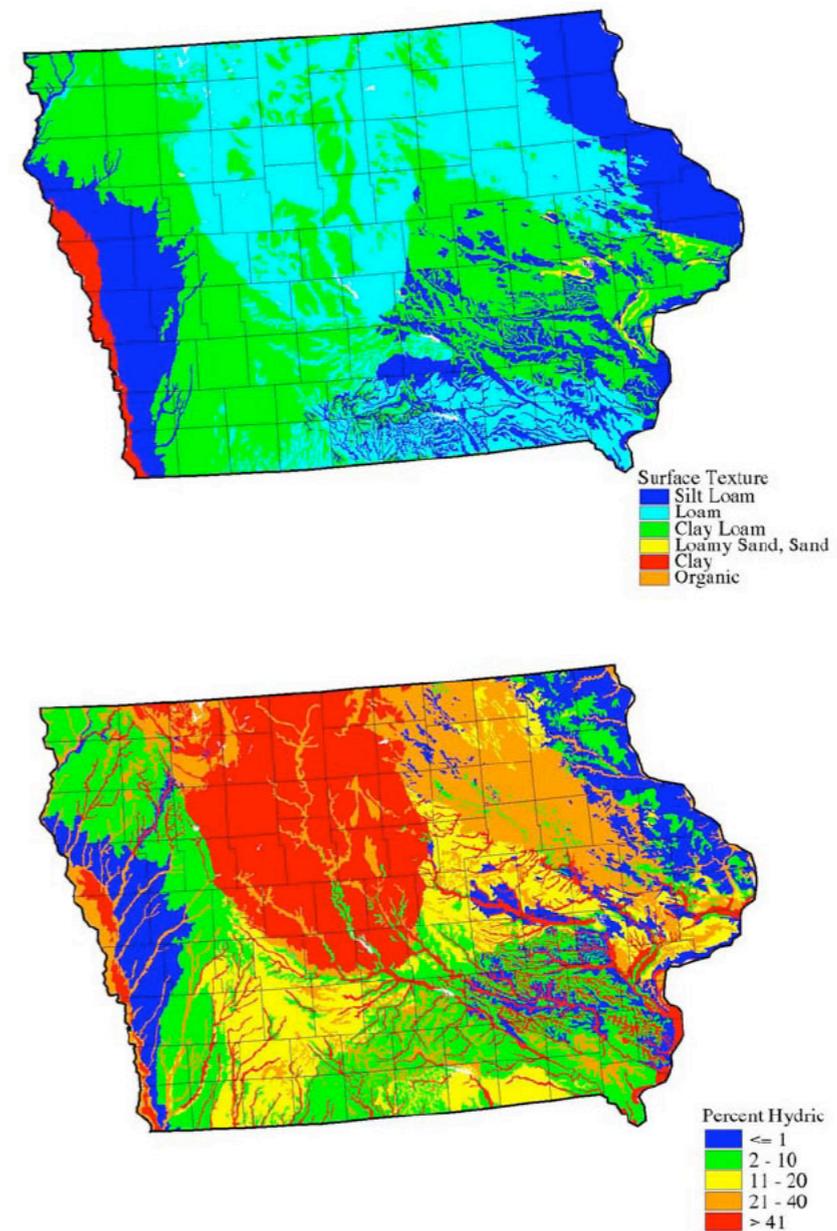


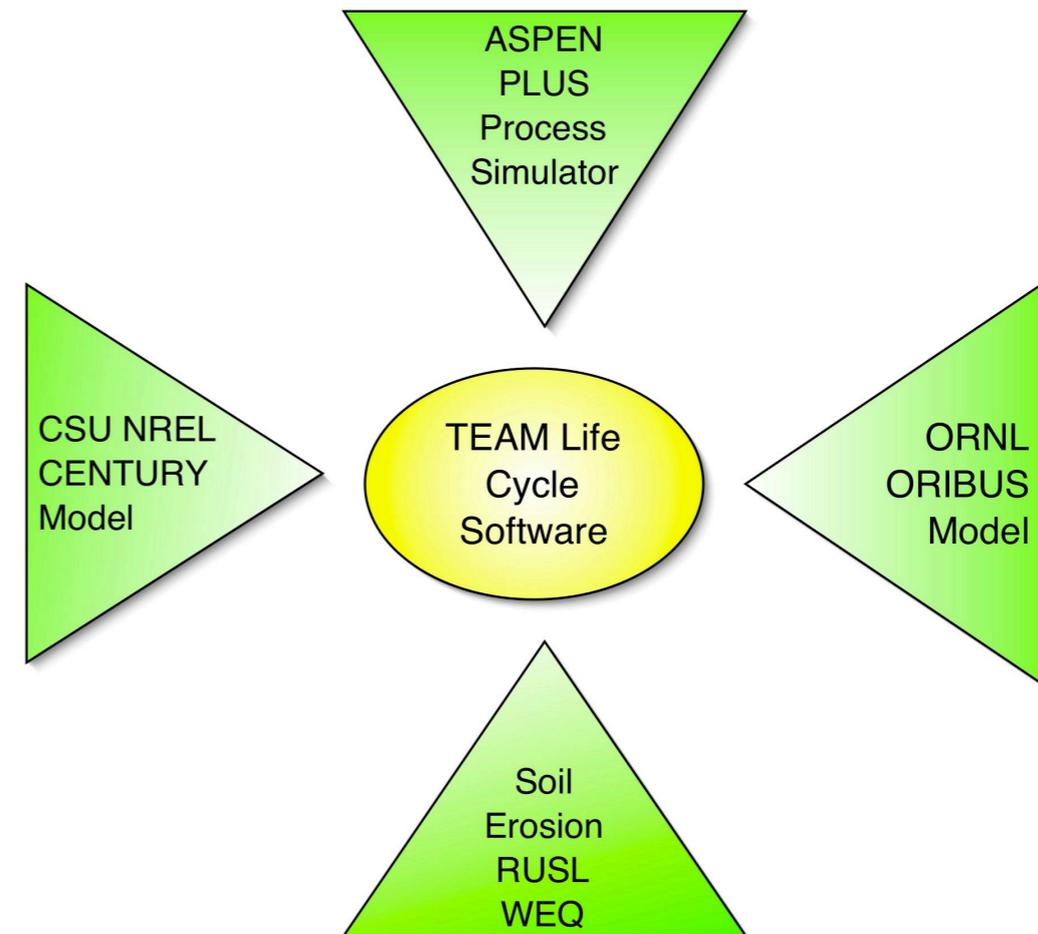
Figure 25: Distribution of soil types in Iowa Used in Soil Carbon Modeling

For each county, area-weighted frequency distributions of soil types were determined based on the relative proportion of soil types. Identification of soil types yielded six to ten soil types per county.



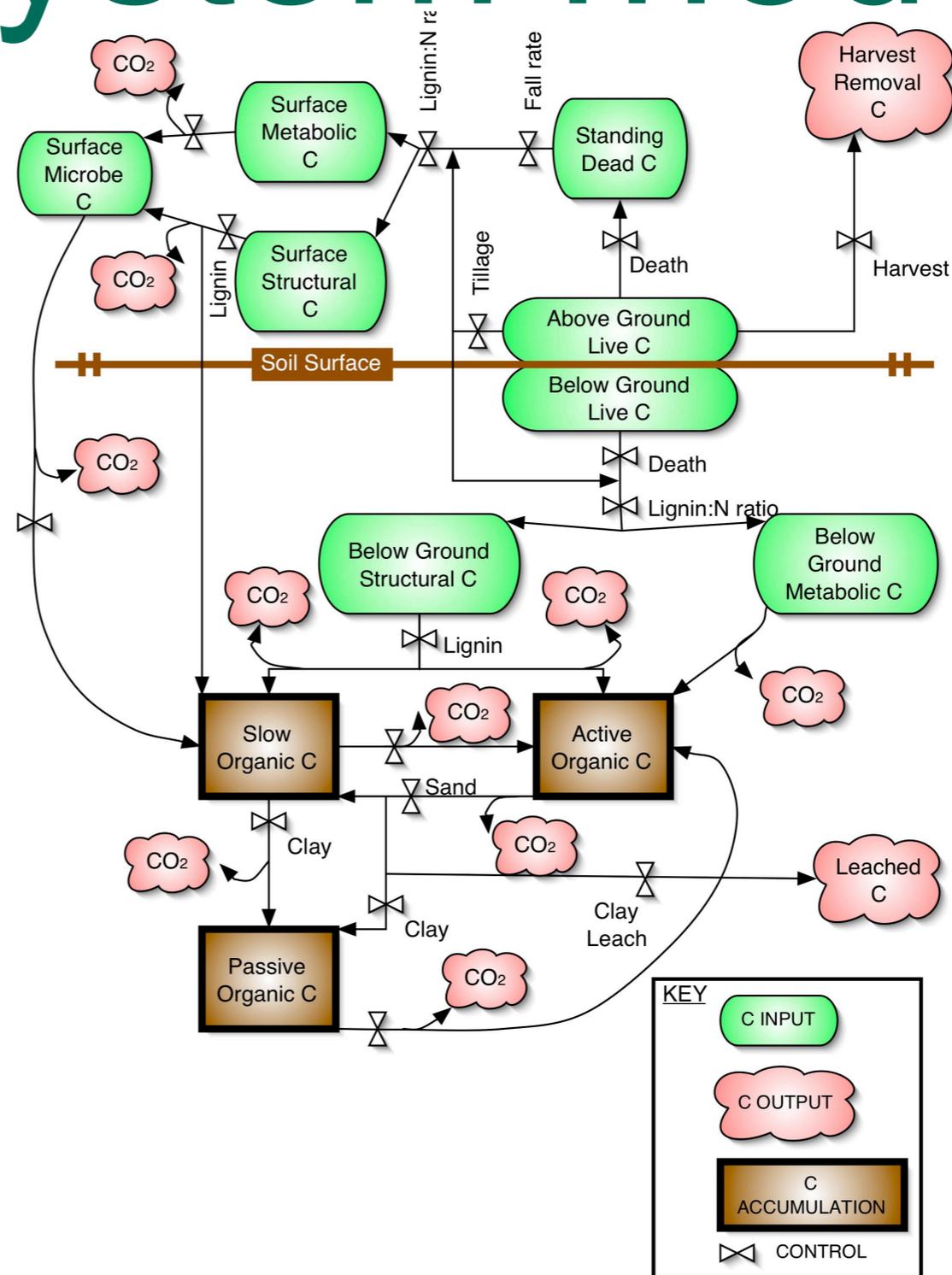
Integrating diverse models

- ✓ TEAM for LCA
- ✓ Century for soil
- ✓ RUSL for Erosion
- ✓ AspenPLUS for process design
- ✓ ORIBUS for biomass transport



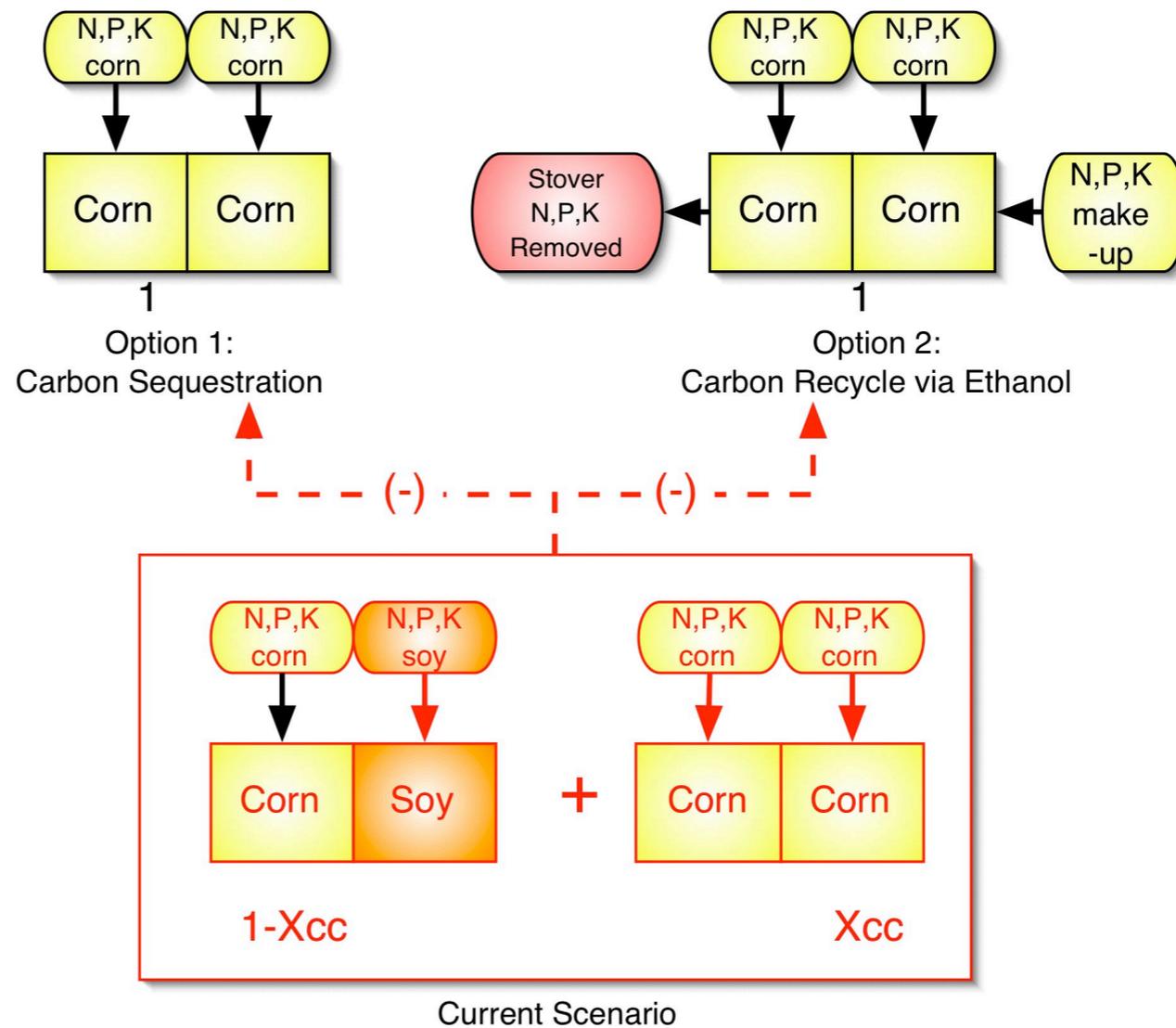
Agroecosystem model

The simple version of the SOM submodel in Century

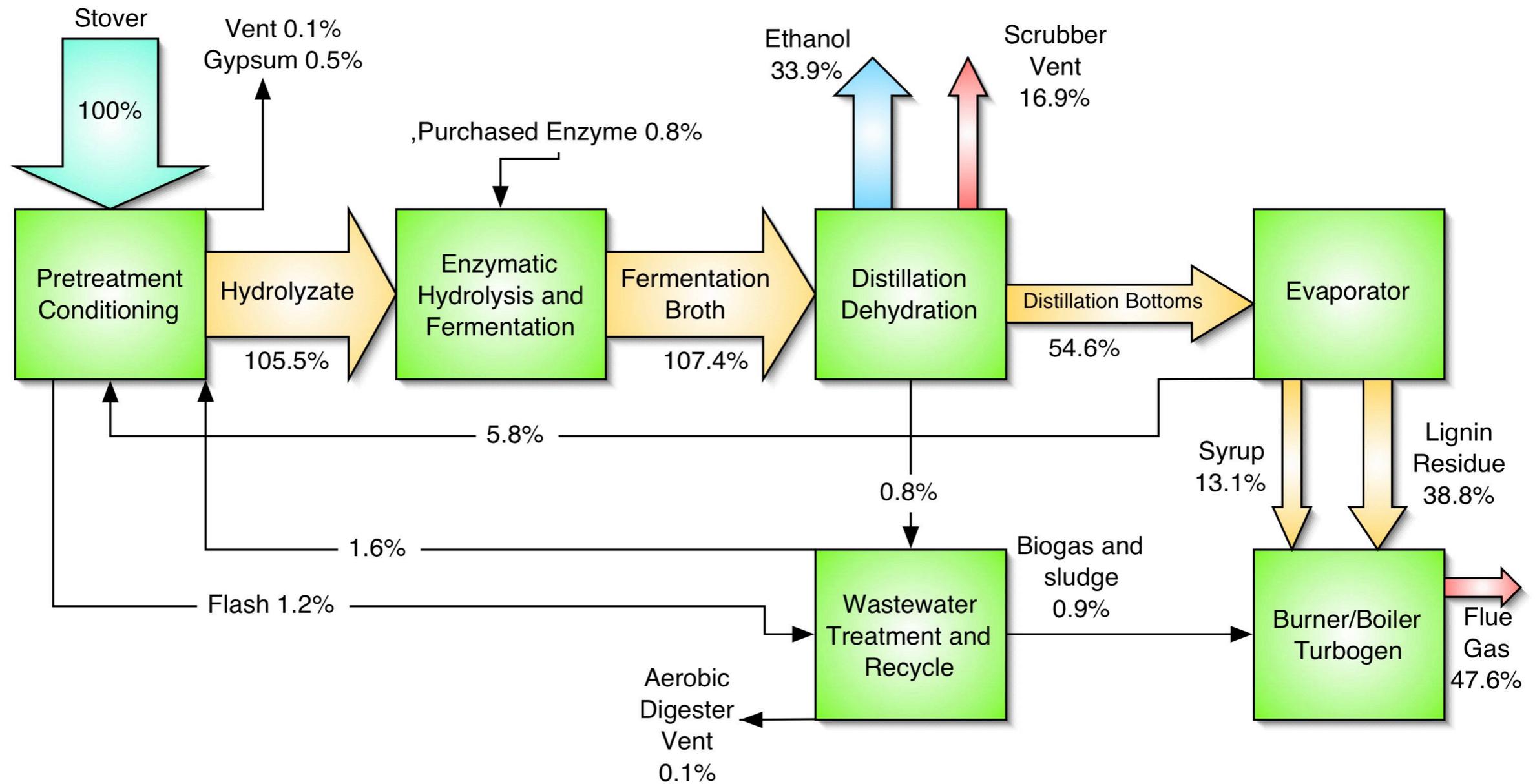


Nutrient management

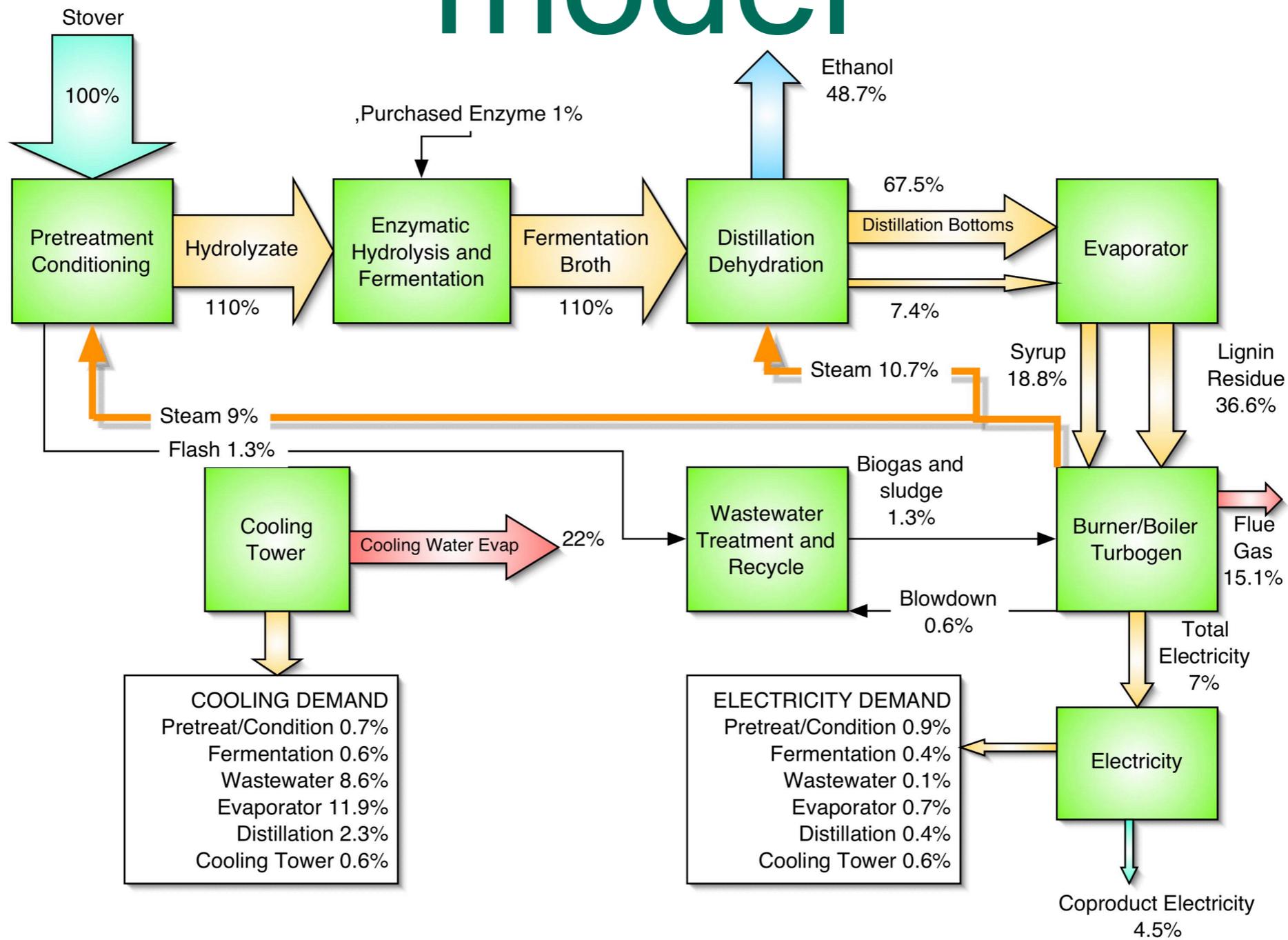
Changes in Nutrient Use Due to Modeled Options



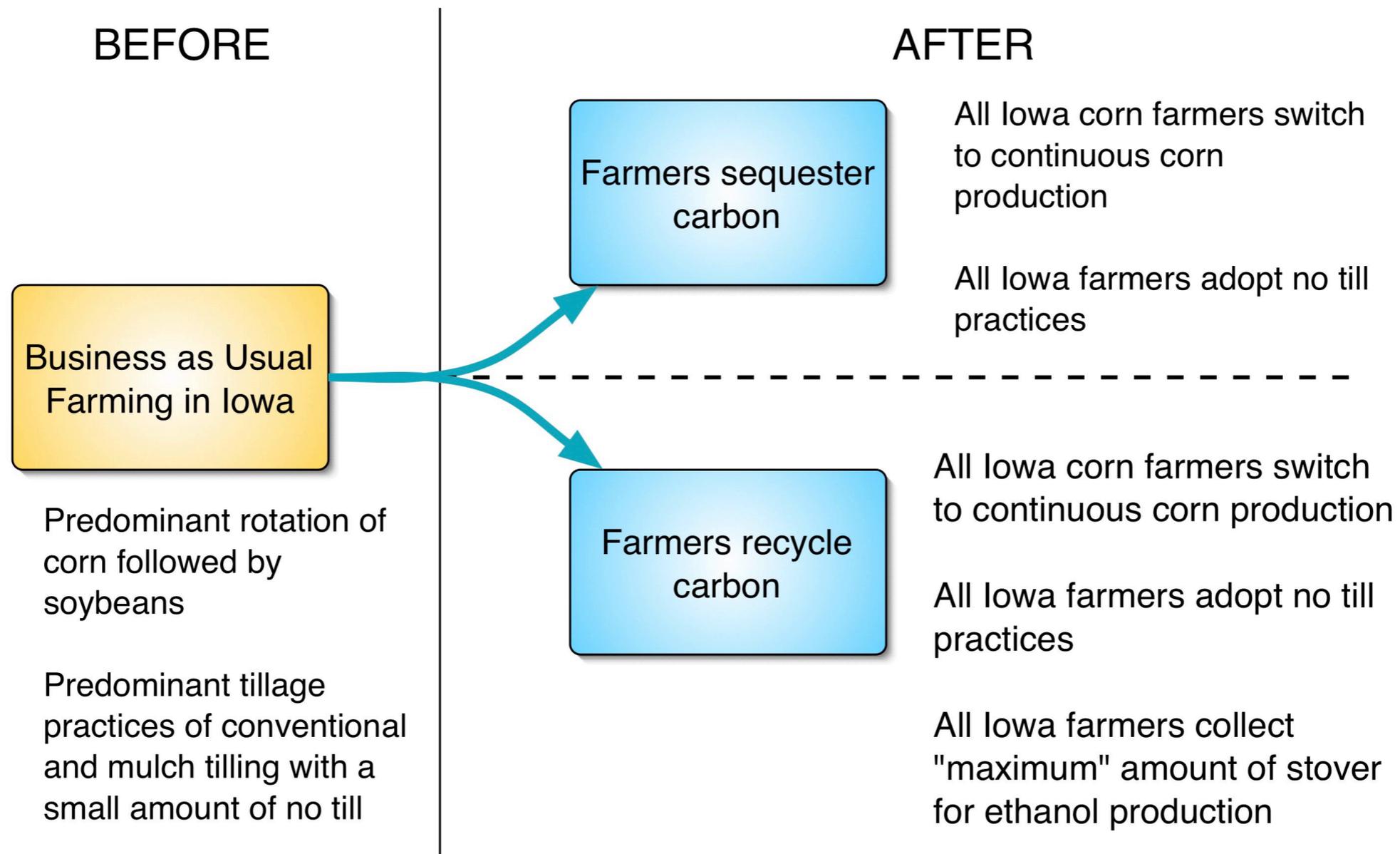
Stover to ethanol model



Stover to ethanol model

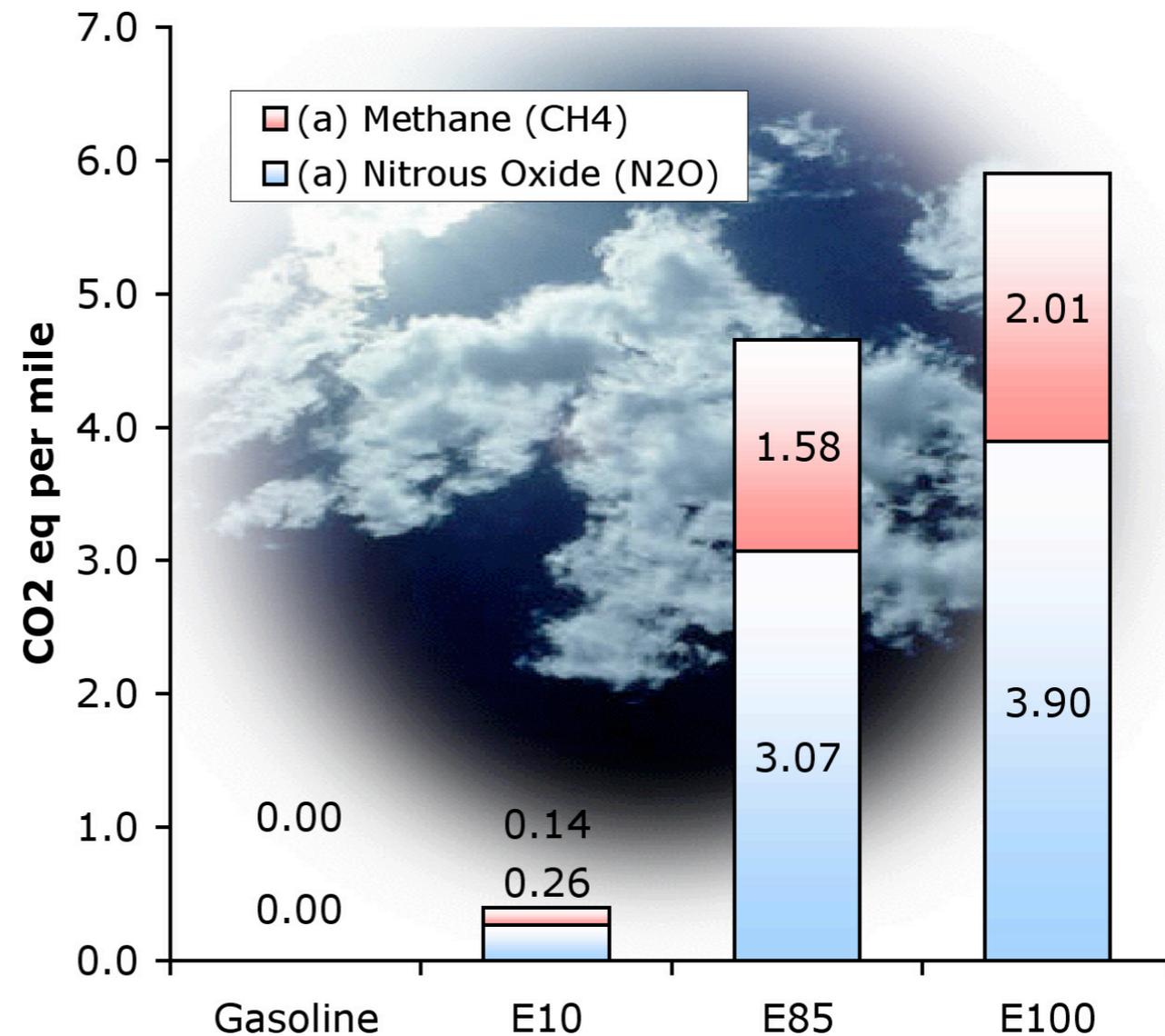


Carbon recycle vs sequester

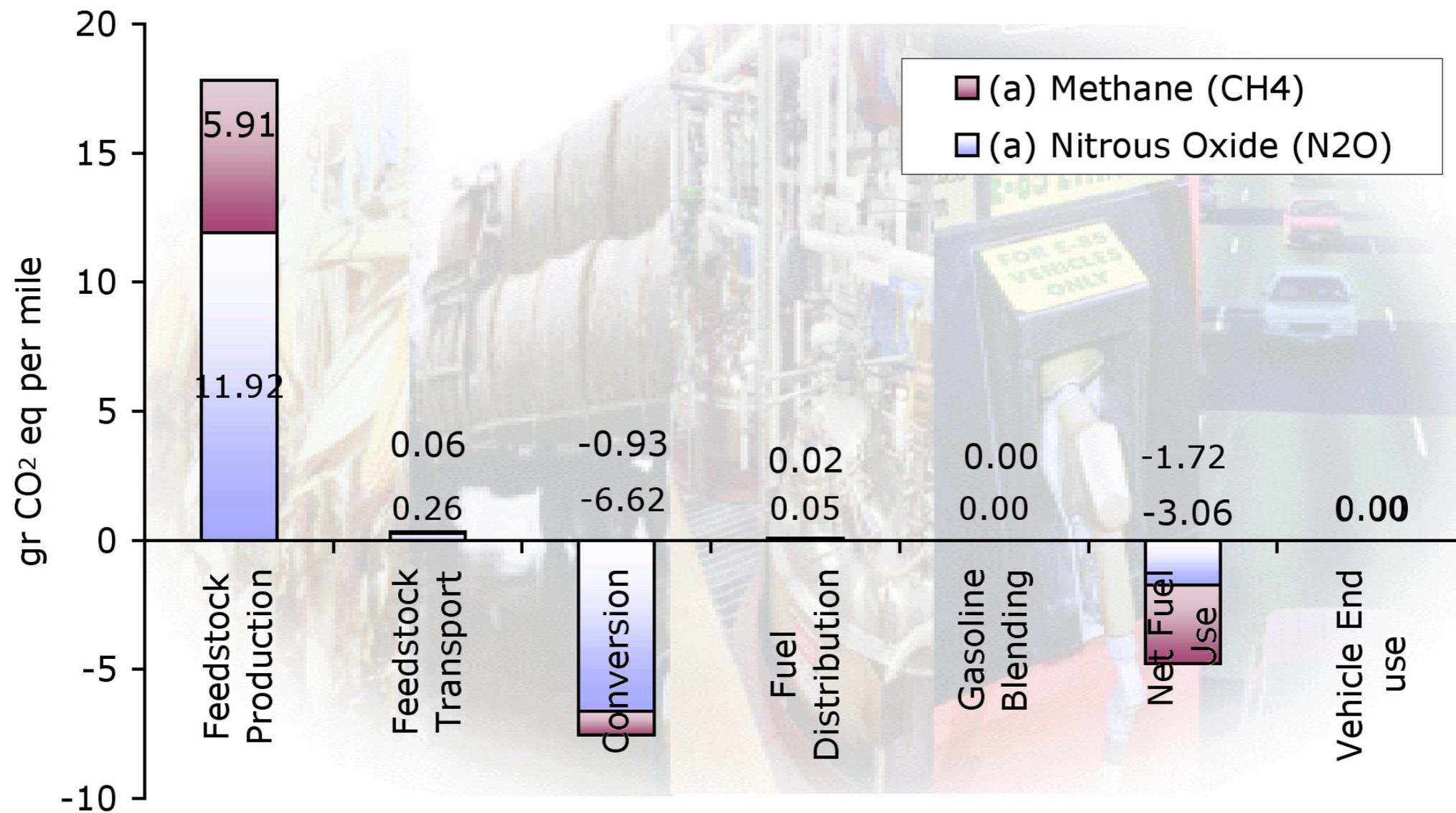


Increased N₂O, CH₄

View from
the car

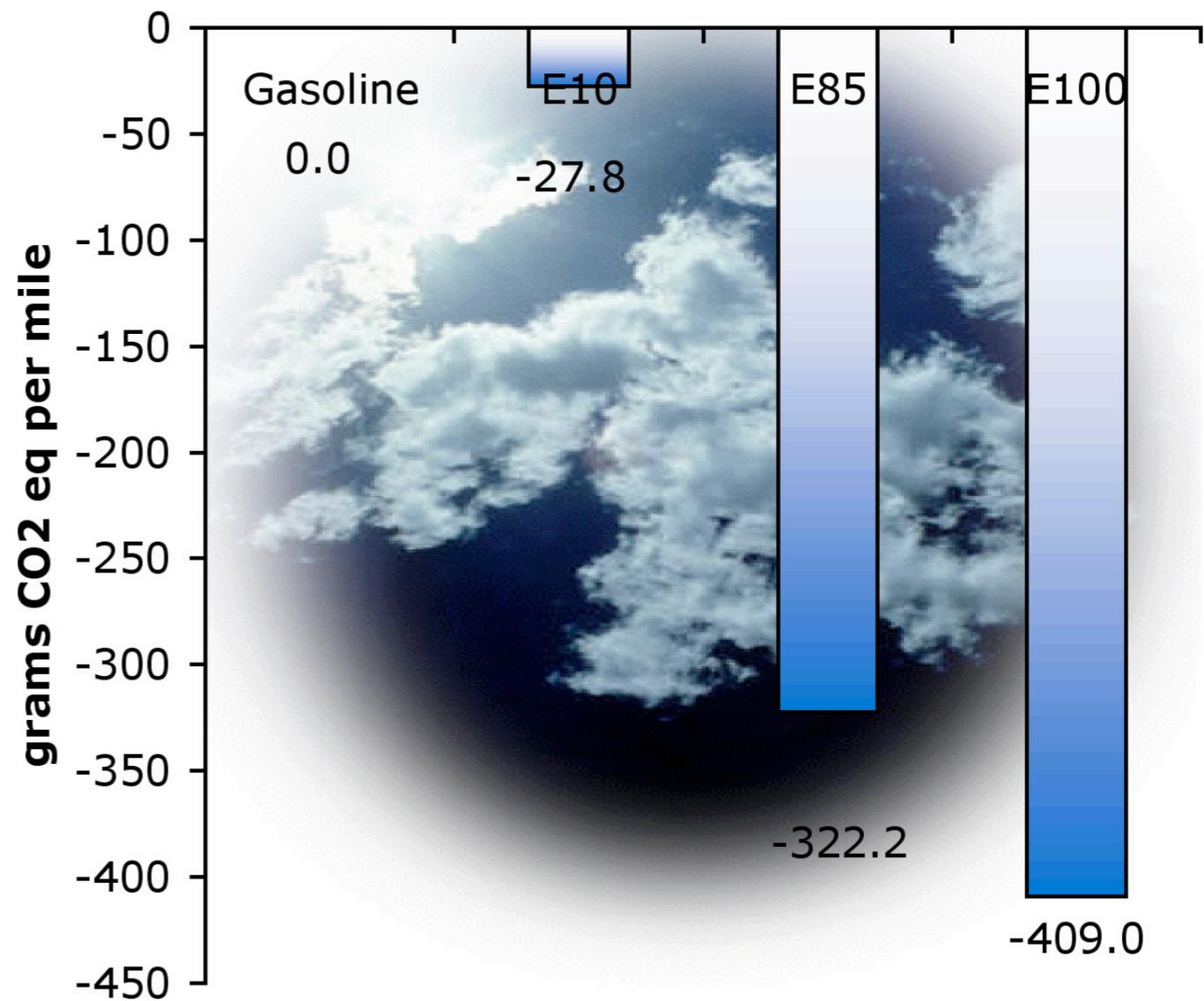


Sources of N₂O, CH₄



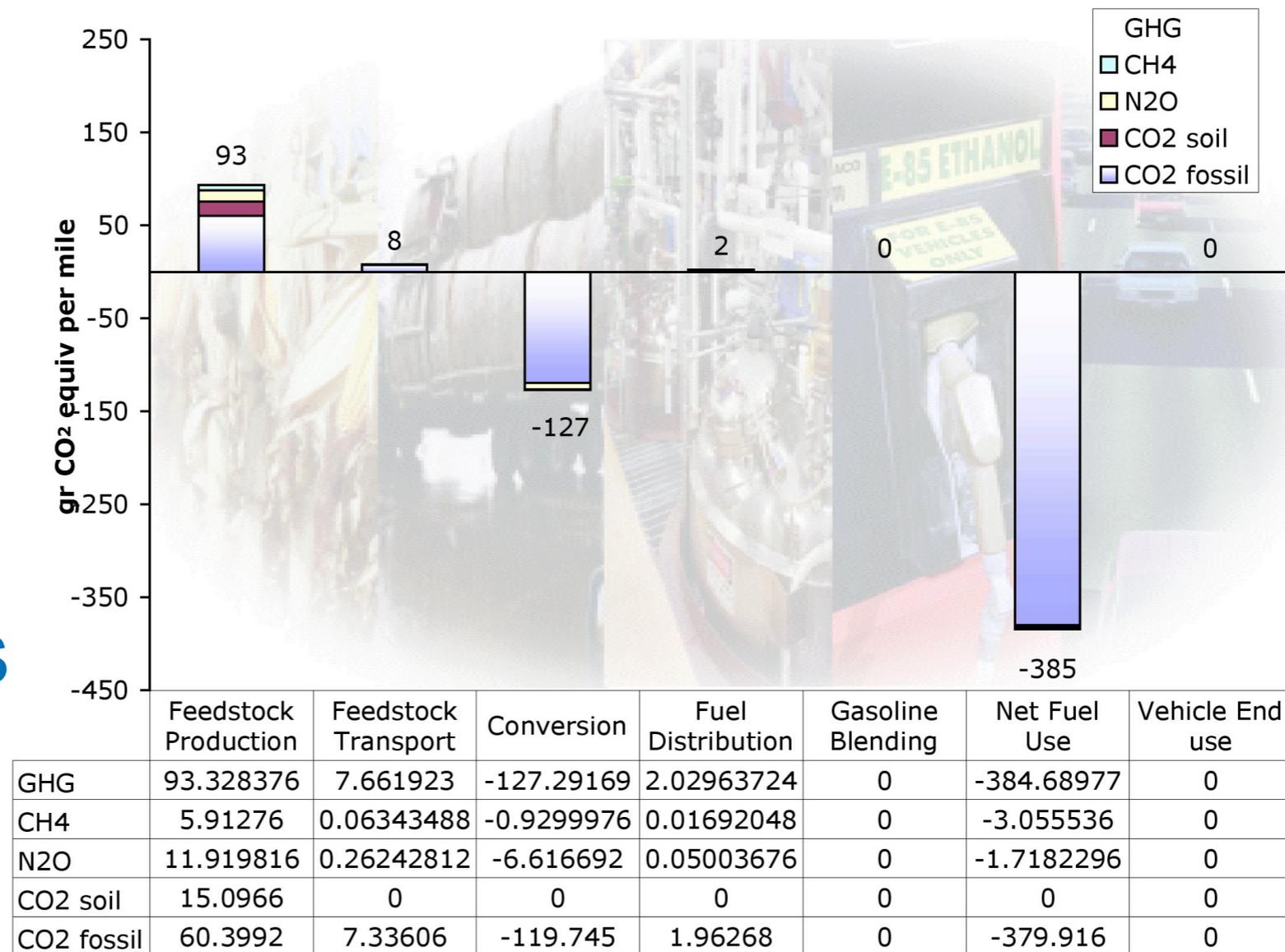
Net GHGs

Even with higher N₂O and CH₄, GHGs are lower

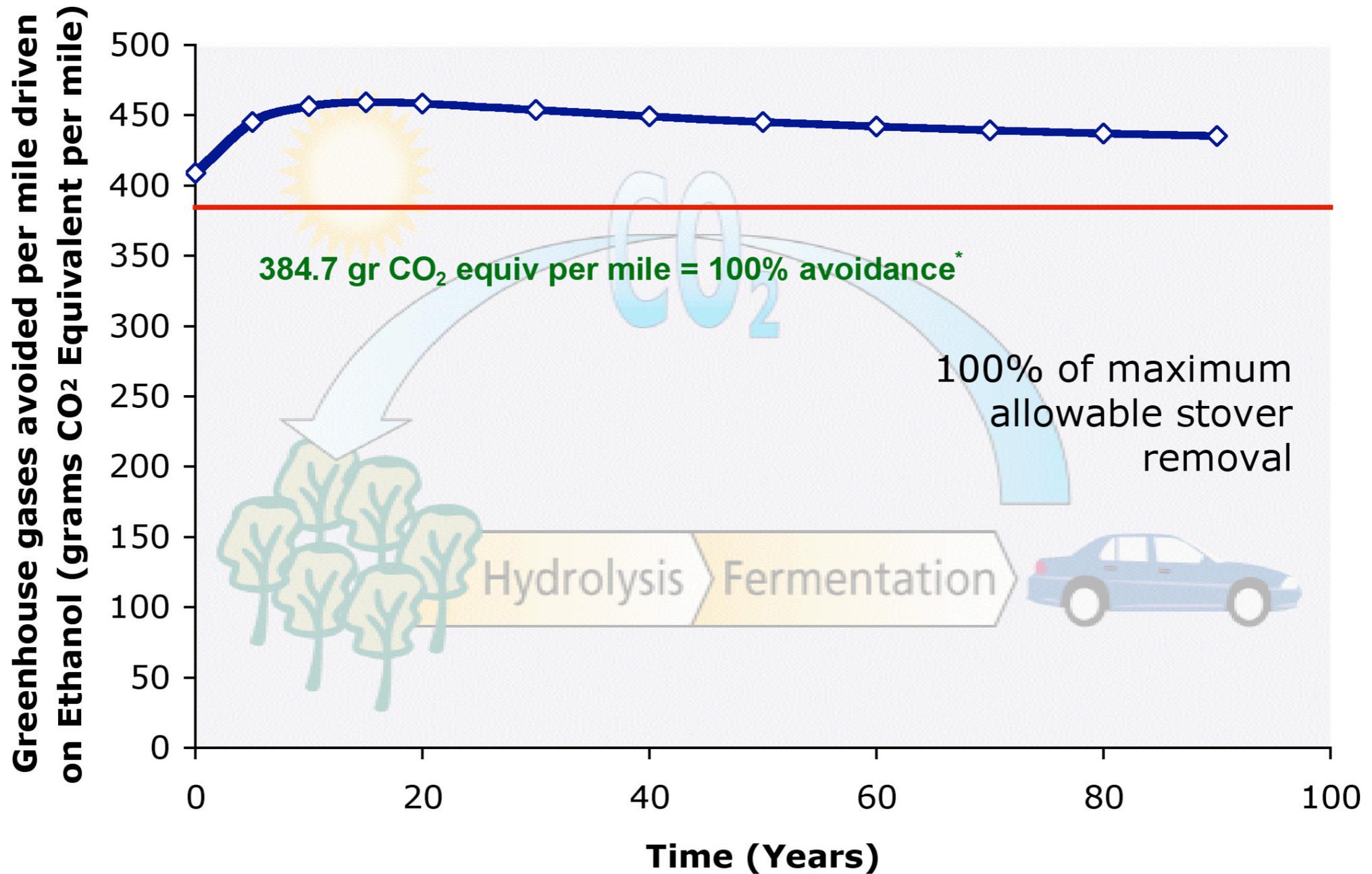


Sources of GHGs

Accounting for soil effects increases farm GHGs by 50%

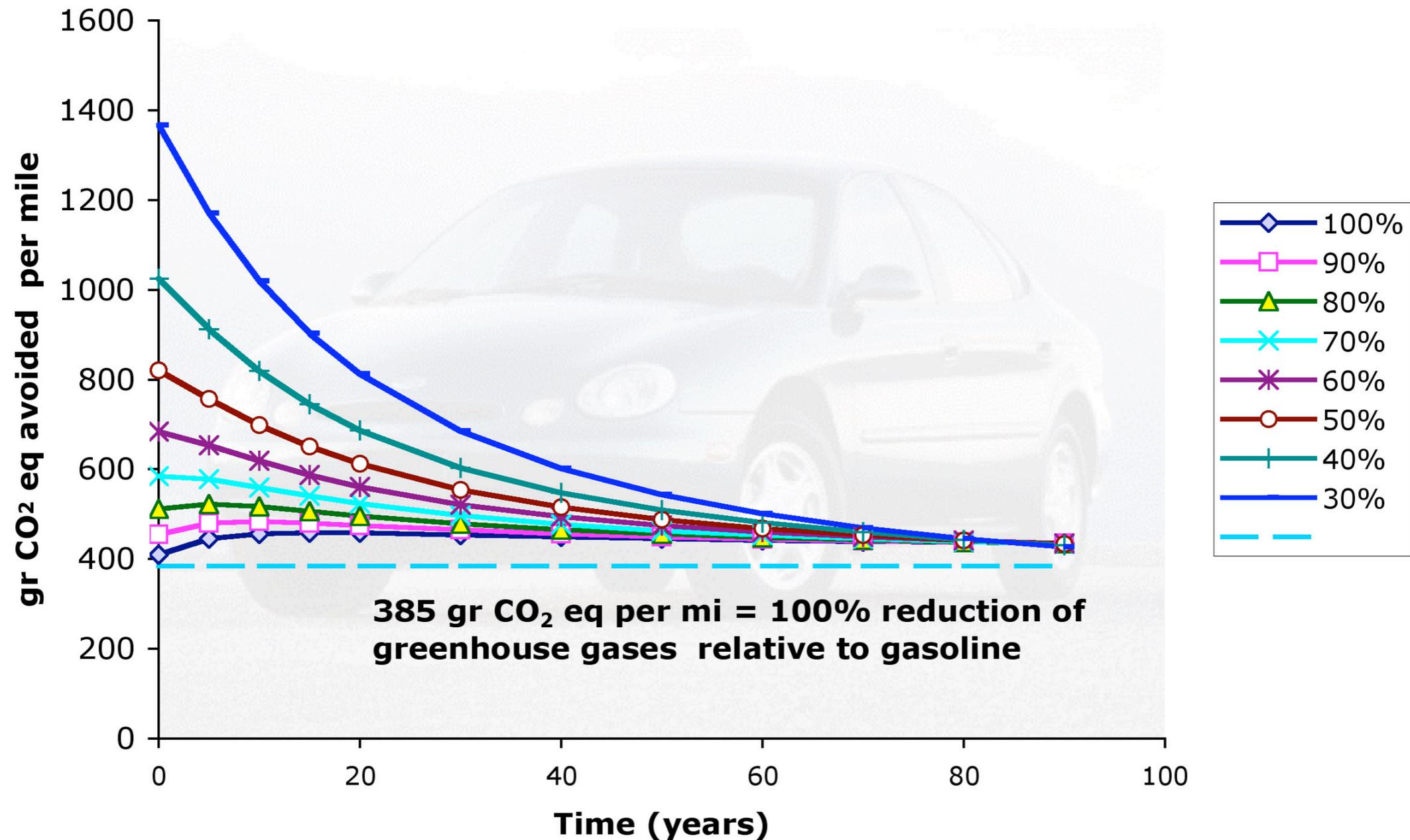


Temporal effect



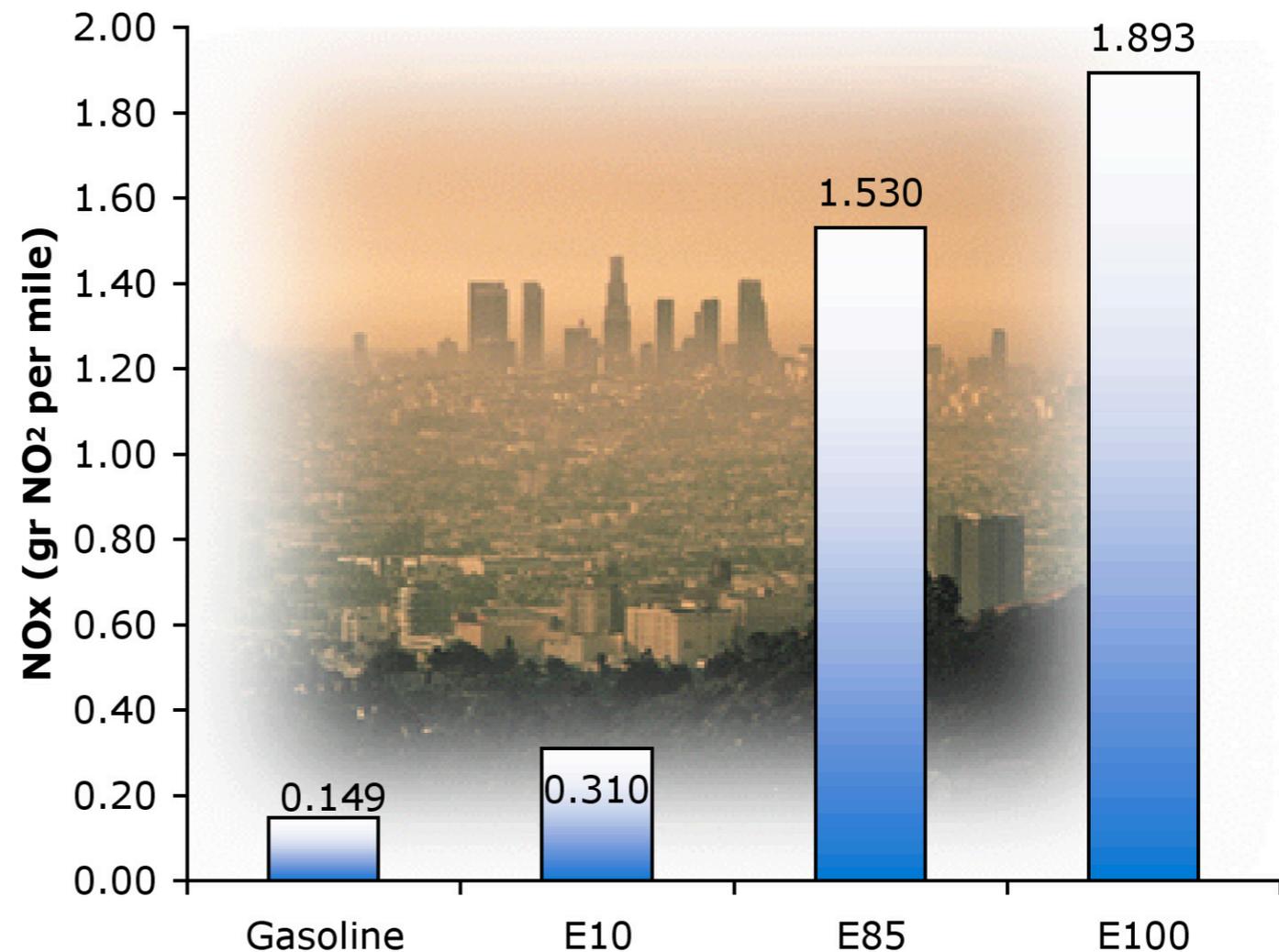
*Driving one mile on unleaded gasoline releases 384.7 grams of CO₂ equivalent.

Recycle vs sequester



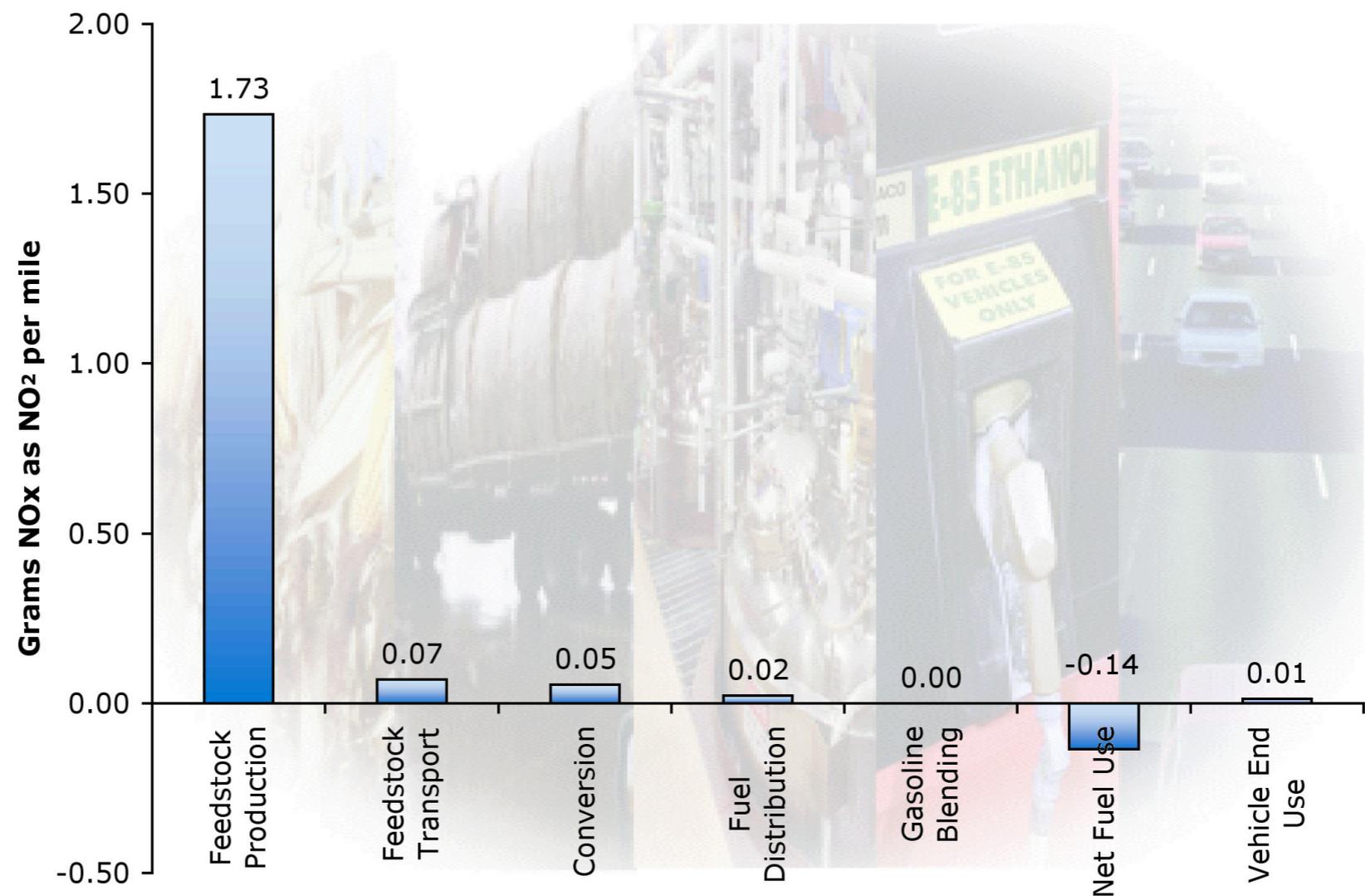
NOx emissions

The perspective of the car shows dramatic problems with NOx

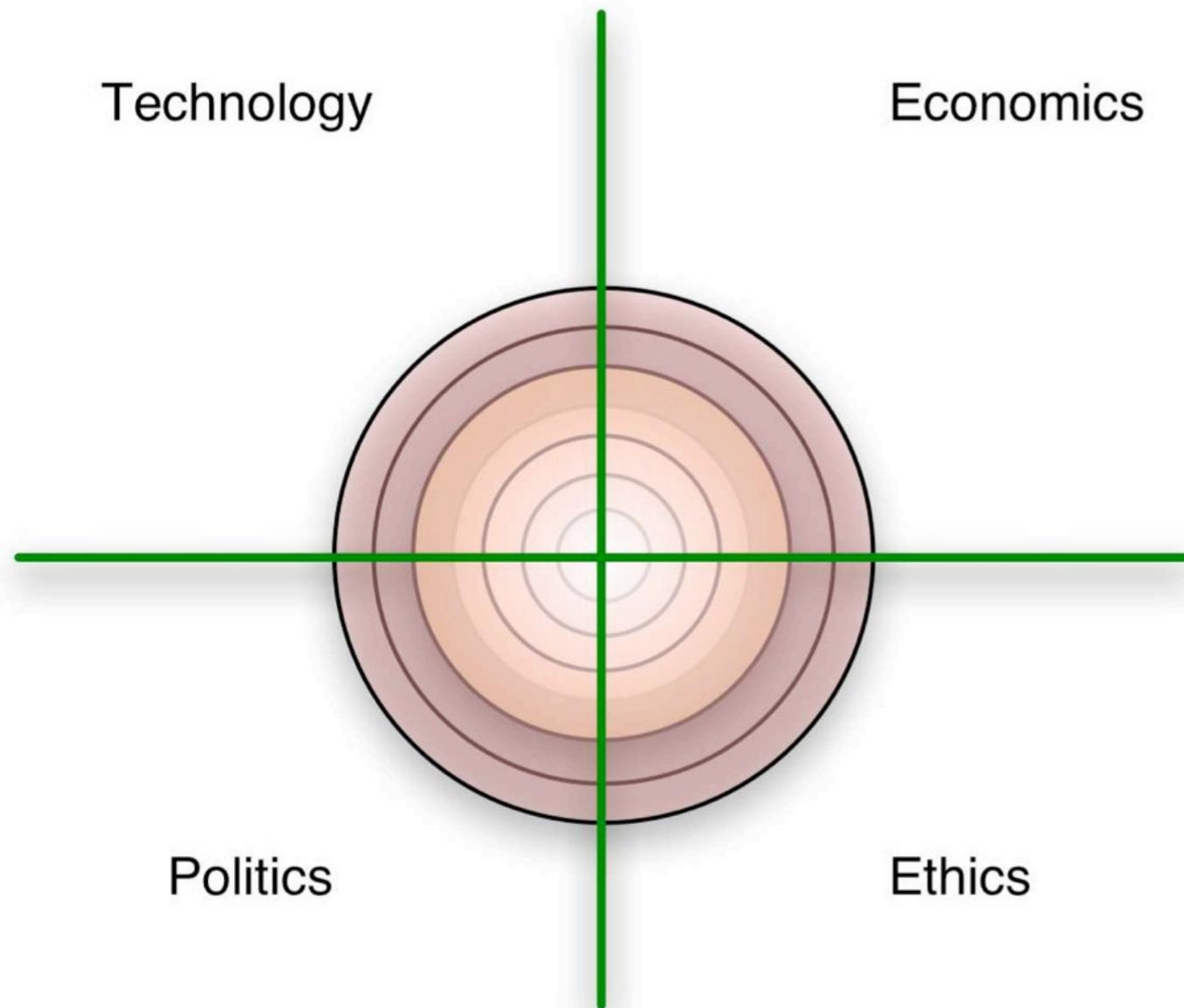


Sources of NOx

86% of farm emissions are from the soil



Ethics and the sustainability of biofuels



E.O. Wilson, *Consilience*

Ethics and the sustainability of biofuels

Quality of life
The tortilla effect



“Thousands in Mexico City Protest Rising Food Prices” *The New York Times*

January 2007

Ethics and the sustainability of biofuels

Quality of life
The brewery effect?



“Biofuel brews up higher German beer prices”
Associated Press, May 2007

“Hops shortage coming to a head

”Rocky Mountain News, January 2008

Ethics and the sustainability of biofuels

Quality of life

Developing countries' developing demand



The Food Chain: A Global Need for Grain That Farms Can't Fill

The New York Times

March 2008

Ethics and the sustainability of biofuels

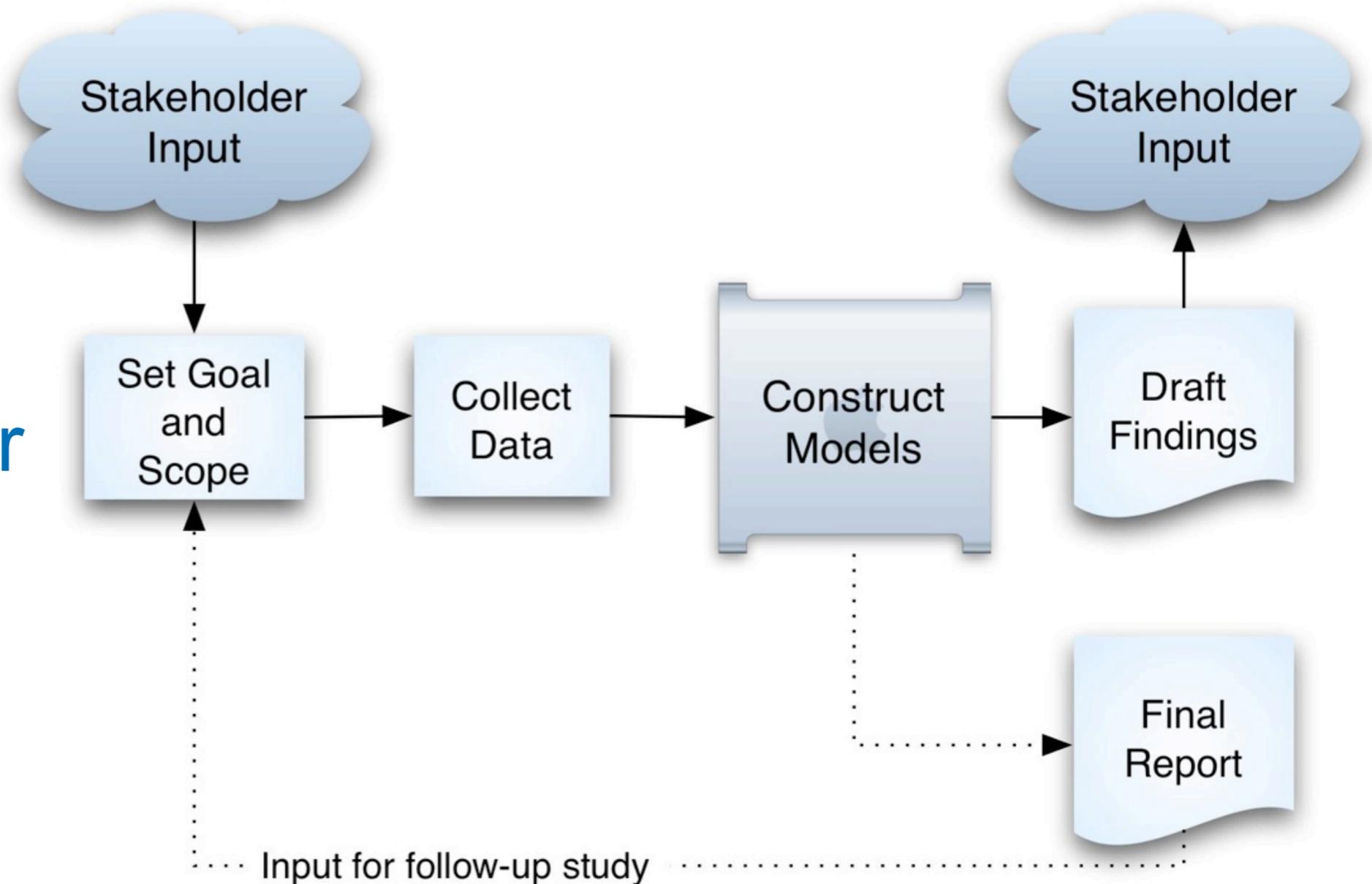
“We need an LCA process that addresses all sustainability issues and is accepted worldwide”

Paraphrased from talk by Dean Simeroth, CARB, commenting on hurdles facing implementation of a low carbon fuel standard in California



Ethics and the sustainability of biofuels

LCA as a framework for dialogue



Ethics and the sustainability of biofuels



“Let us engage in the serious business of conducting our discussion rationally and logically to discover the truth about points on which we differ.”

—Mortimer J. Adler

Algae's renaissance

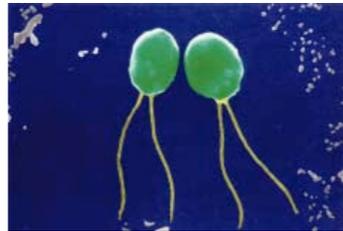
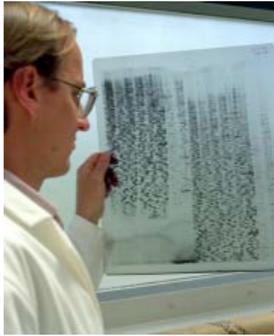
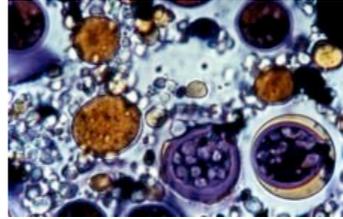
Two years ago, my phone at
NREL began ringing off the
hook with inquiries from
investors

Our close-out report on algae
is now the #1 download on
NREL's website

National Renewable Energy Laboratory
NREL

NREL/TP-580-24190

A Look Back at the
U.S. Department of Energy's
Aquatic Species Program:
Biodiesel from Algae



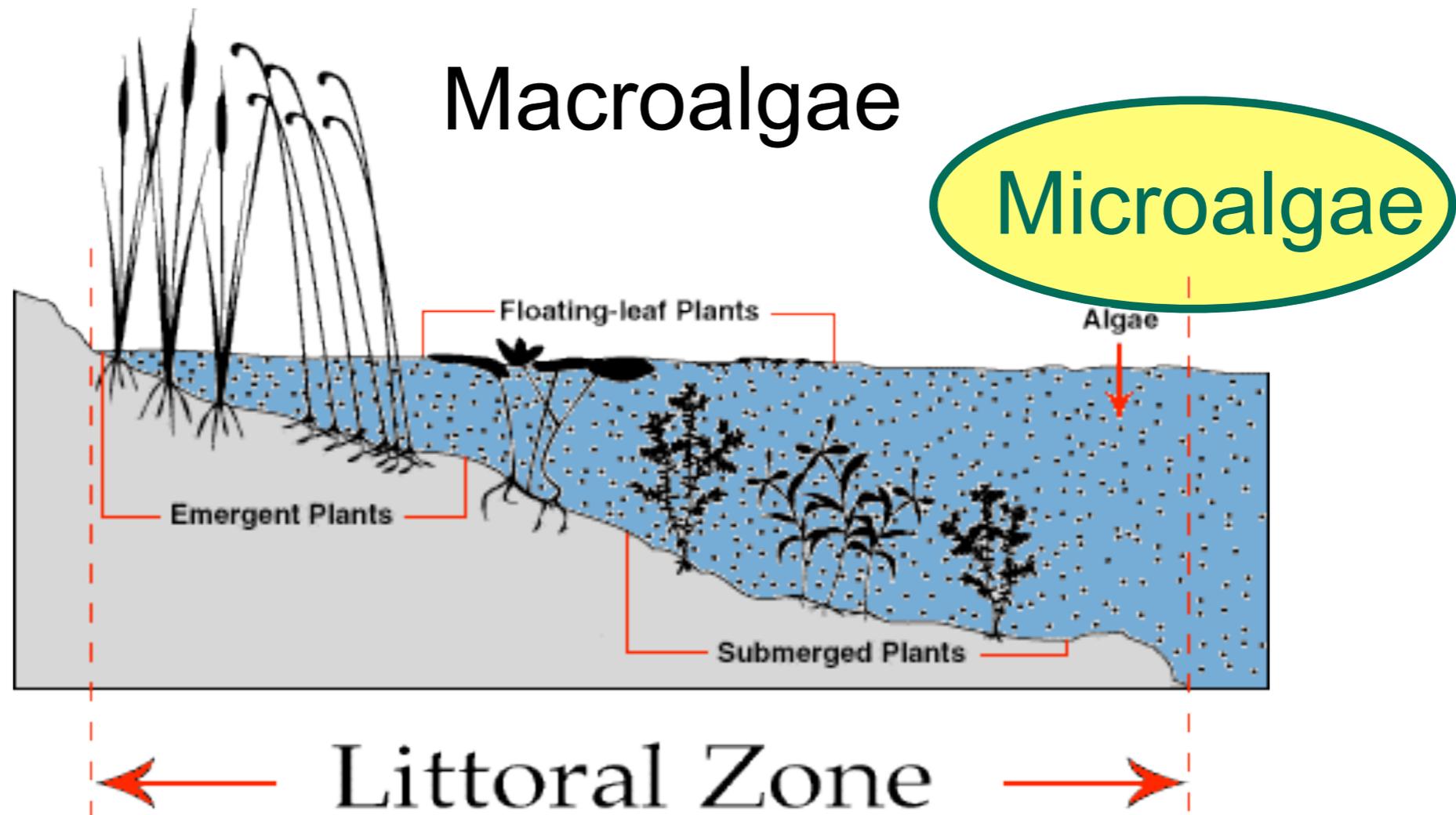
Close-Out Report

www.nrel.gov



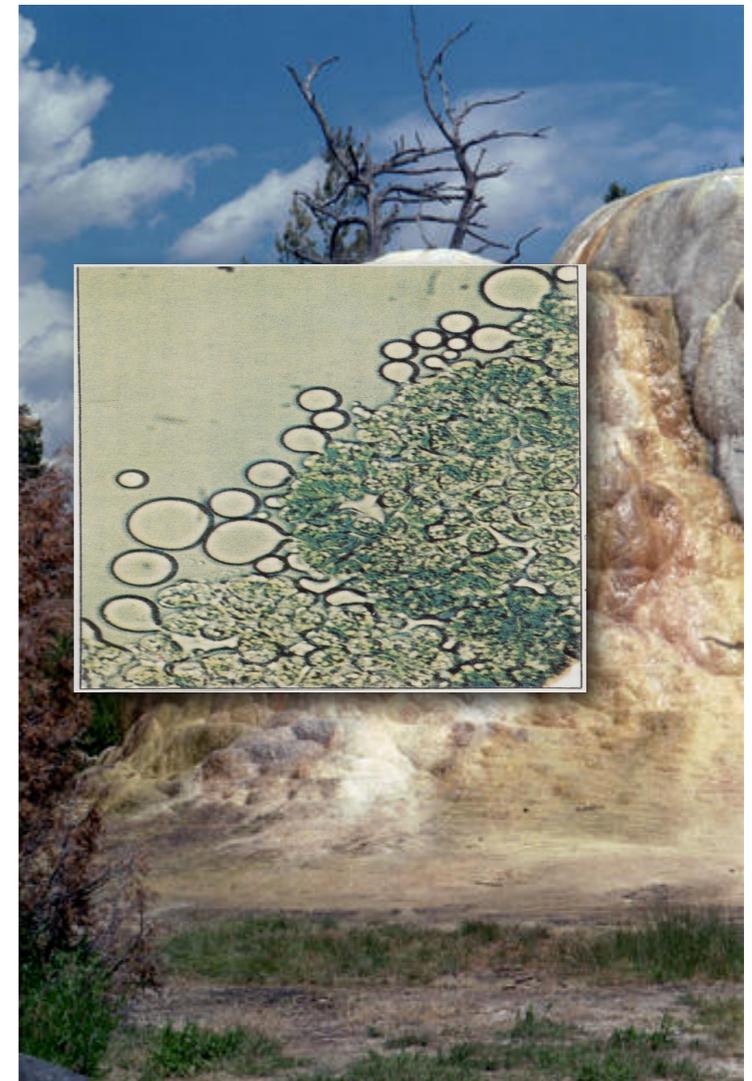
Algae—the other biomass

Emergents



Algae—the other biomass

- ✓ A High-Risk, High-Benefit Opportunity
 - Prehistoric plants that grow where few other plants could survive
 - Hot climes
 - Salt water



NREL's production concept was a new kind of farming

- ✓ The open ponds
- ✓ Recycle CO₂ from power plants

